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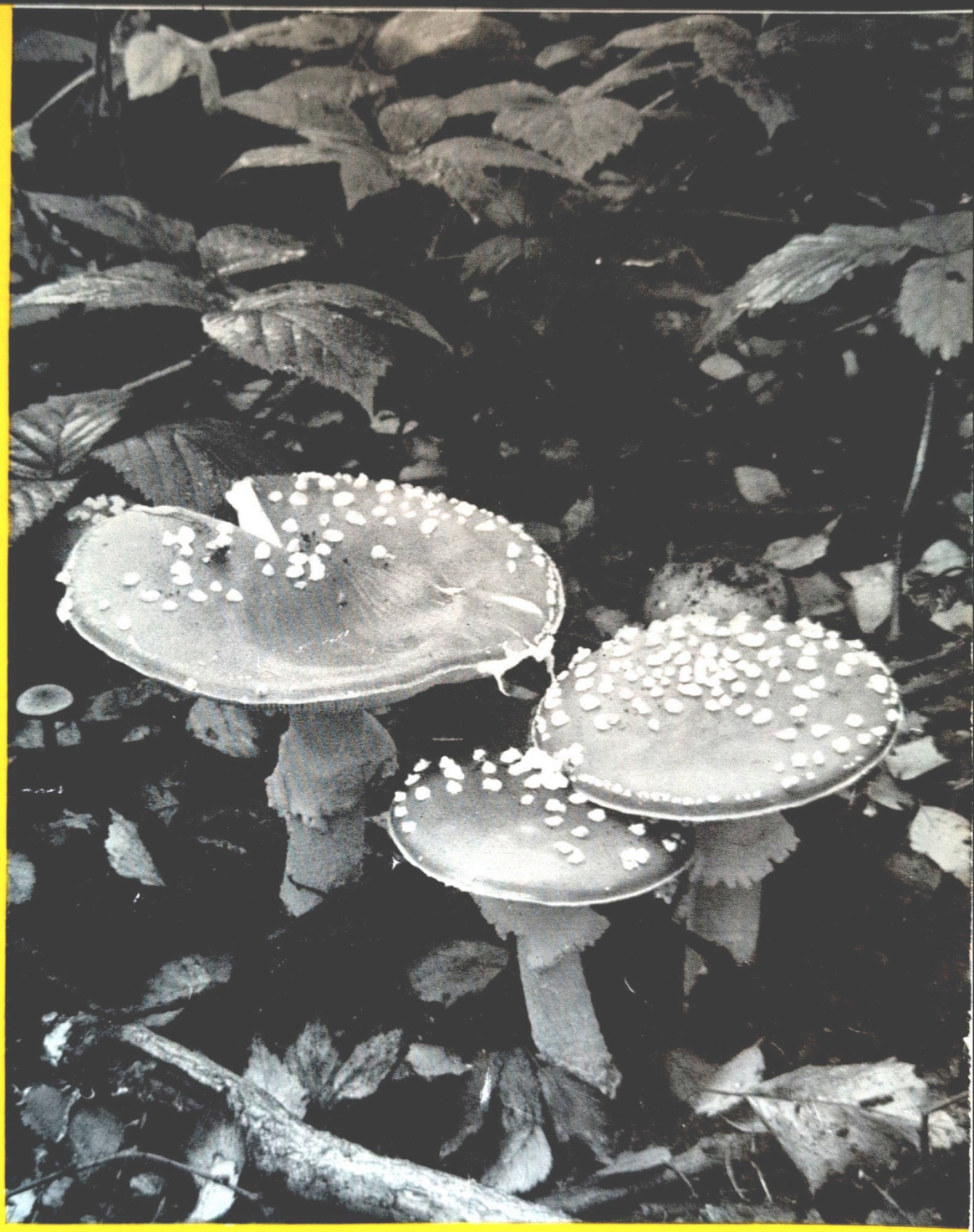

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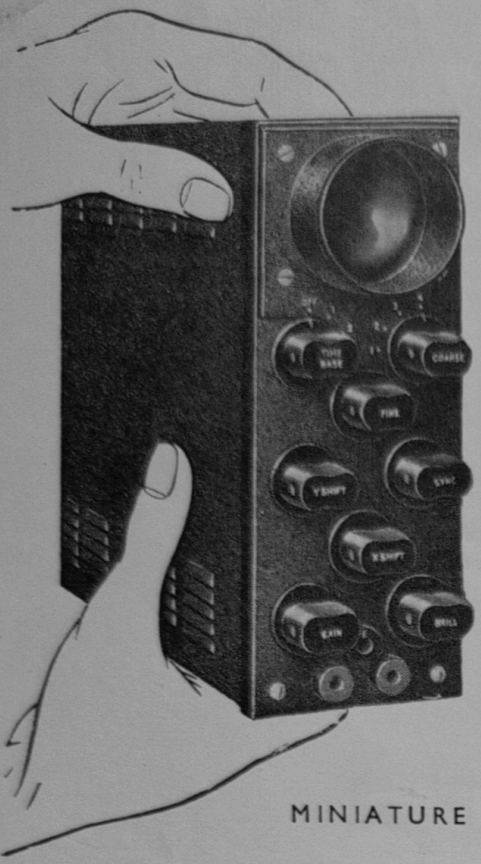

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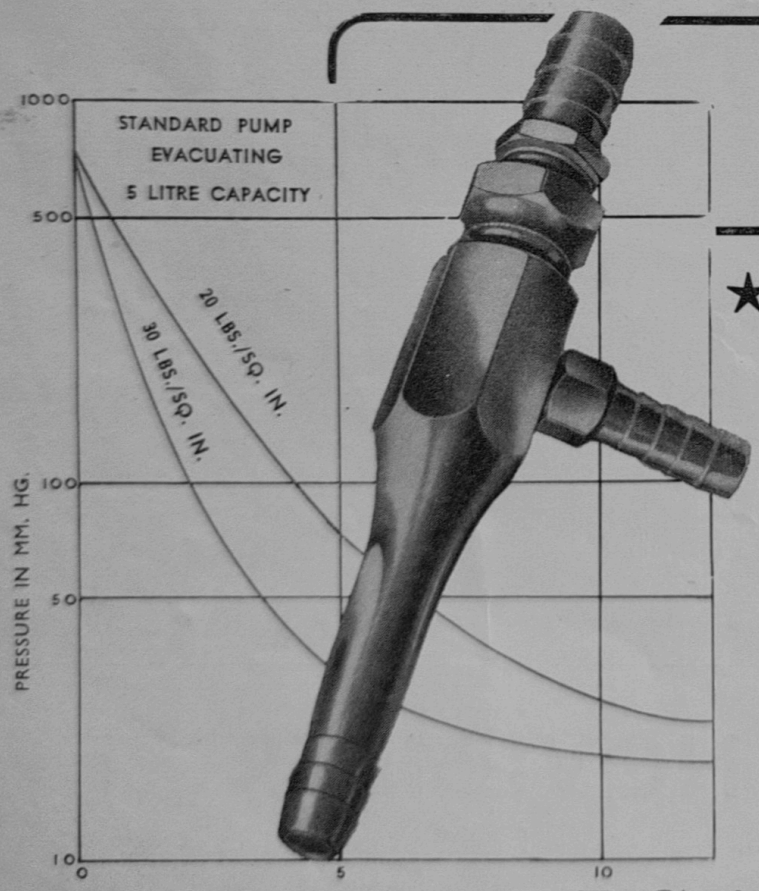

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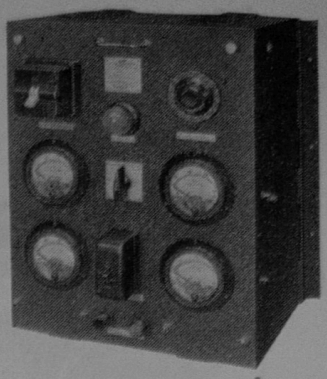

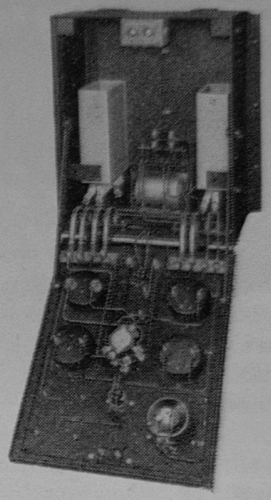

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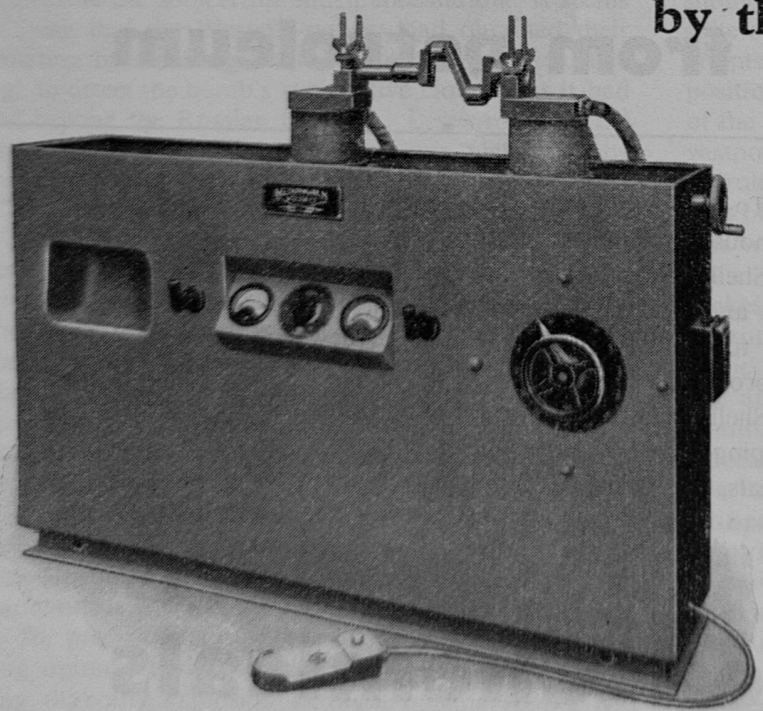

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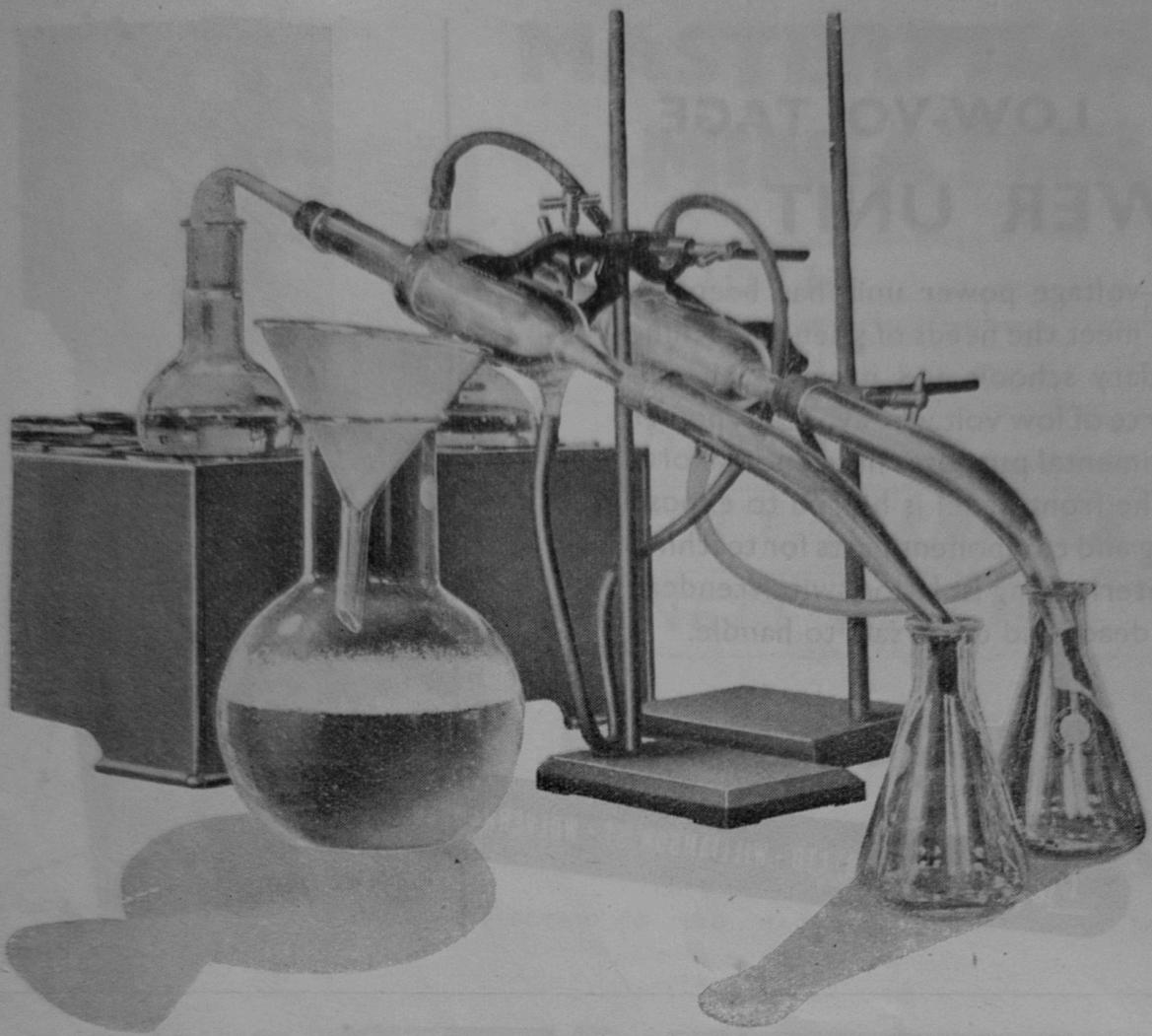

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DISCOVERY

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Editor WILLIAM E. DICK, B.Sc., F.L.S.
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The Progress of Science

The Russian Atomic Bomb

SEPTEMBER 23, 1949, is a key date in the chronology of the Atomic Age. On that day the Governments of the United States, Britain and Canada announced that the Russians had effected an atomic explosion within recent weeks. The official statements made in each of the three countries which were wartime partners in the development of the first atomic bomb were short, clear and devoid of any propaganda tinge. Parliamentary questions extracted no further facts about the explosion from the authorities in the three countries, and neither did the questions of newspaper men.

The authorities were not prepared to disclose, for instance, how the explosion was detected. This particular point became the subject for much speculation. It seems most likely that the Western powers had obtained their information by espionage, aided by instruments sensitive enough to detect the bomb's radioactive cloud after it had passed beyond the Russian frontiers. Less probably, the earth tremor produced by the bomb was picked up by seismographs, and even more improbable was the idea that the resulting shock wave in the earth's atmosphere had been picked up by ultra-sensitive barographs.

Unofficial reports put the date of the explosion around September 1. It was also suggested that the bomb was exploded on land and not underwater, and that the explosion was less intense than that produced by the first test bomb exploded in America.

Up to the time this issue went to press no one in a position of authority in Russia has commented on the announcement about the bomb. True the official Soviet news agency, Tass, released a statement which was published in all Soviet newspapers. One can automatically rule out the idea that the statement was written frivolously or carelessly, and therefore one is left with the conviction that it was designed solely for propaganda purposes with the intention of misleading opinion both at home and abroad. It began by hinting that any explosion detected outside Russia had nothing to do with a war-like atomic bomb. It said that in Russia the 'latest technical means' are used for routine blasting operations in connexion with canal and road building, and the reader was evidently intended to take this to mean that Russia had now so much U235 or plutonium at its disposal that atomic explosives could be used for everyday blasting operations. No one outside Russia was likely to be misled on this point. The radioactive by-products of an atomic explosion clearly preclude the use of atomic explosives for the purpose for which the Tass report hinted they are being used.

The Tass statement then proceeded to convey the idea that the Russians had known all there was to know about the bomb two years ago, supporting this claim by reference to Molotov's casual mention of the atomic bomb on November 6, 1947 (when he said ". . . expansionist circles in the United States . . . rely on the secret of the atom bomb, although this secret has long ceased to exist.")

The rest of the Tass statement was as follows: "It should be pointed out that the Soviet Government, in spite of the existence in its country of the atomic weapon, adopts, and intends adopting in the future, its former position in favour of the absolute prohibition of the use of the atomic weapons. Concerning control of the atomic weapon, it has to be said that control will be essential to corroborate the fulfilment of the decision on the prohibition of production of the atomic weapon." These remarks one would like to be able to treat in all seriousness, but their context within a wholly propagandist statement makes that impossible. One would also like to be able to accept at face value the proposal to the United Nations General Assembly which Mr. Vyshinsky made on the day the announcement was made about the Russian atomic bomb. He proposed that the General Assembly should "declare the use of atomic weapons to be incompatible with the 'conscience and honour' of member States, who should proceed without further delay to the adoption of a rigid system of international control". It remained for Mr. Vyshinsky to say that Russia was now prepared to adopt such a system of atomic control, but he said nothing further on the subject. International control was, in fact, brought no nearer by anything that was said by any statesman on September 23.

The word 'devaluation' was much in the air on that day, so it was scarcely surprising to find that several glib writers could not resist the temptation to 'devalue the atom bomb'. Most of the snap judgments on the strategic

implications of Russia's possession of the secret of making atomic bombs were not worth the paper on which they were written. E. M. Friedwald's article in this issue considers the strategic implications of this event and puts it in its true perspective.

Cytochrome

IRON is a mineral, without which life, as we know it today, probably could not exist; for iron is an essential constituent of two substances which are of fundamental importance to the body.

The first of these substances is *haemoglobin*, which transports oxygen to every corner of the body, and the second is *cytochrome*,* by means of which oxygen is utilised by the tissues.

Cytochrome and haemoglobin both consist of a chemical group containing iron attached to a protein. The protein is different in the two cases, but the chemical groups containing iron are surprisingly similar in the two compounds.

The history of the discovery of the cytochromes is of great interest. It started way back in 1918 when Professor Otto Warburg, working in Germany, found that all cells that normally used atmospheric oxygen appeared to have a catalyst which facilitated the activation and use of oxygen by them for the purposes of respiration. Warburg knew that many iron compounds existed which had the effect of catalysing the oxidation of a number of organic substances, such as, for example, the amino-acids. Even in its inorganic form iron possesses a significant catalytic ability, but Warburg showed that it was most effective in this respect when it was combined with nitrogenous substances, e.g. proteins.

He found that the gas carbon monoxide stopped the respiration (i.e. the utilisation of oxygen) by living cells, and he knew that carbon monoxide formed complexes with heavy metals, such as iron and copper. Now light can break down the iron carbon monoxide complex, and Warburg found that exposure of cells treated with carbon monoxide to light would restore the physiological *status quo*, the cells commencing to respire again, and to take up oxygen in the normal way. Light has no effect on the copper carbon monoxide complex. Warburg concluded therefore that the catalyst in cells contained iron. This was a most important conclusion and was all the more remarkable since Warburg had never isolated or seen the enzyme itself.

Later Dr. D. Keilin of the Molteno Institute in Cambridge observed in a micro-spectrograph certain absorption bands in the spectrum of the light passing through the muscles of insect's wings. It is known that the position of absorption bands in the spectrum indicates the presence of specific substances in the medium through which the light is passing. Now *this* observation of Keilin's was not in itself so important, but what was of intense interest was the fact that as he watched he saw the absorption bands change position, and that this coincided with contraction of the living muscle of the insect. He realised that this meant that the substance causing the original absorption bands was probably undergoing oxidation and reduction in the process of muscular contraction and relaxation. Later Keilin found this substance (which he christened 'cytochrome') to be widely distributed in cells, and that it was in fact identical with a pigment discovered towards the end of the nineteenth century and called 'histohaematin'. Later he showed there was a correlation between the respiratory activity of various cells and the amount of cytochrome they contained.

It now appears that there is some possibility that this fundamental work may find practical application in medicine. Cytochrome C has been used with good results, it is claimed, for treating certain vascular disorders. Drs. Klinjman and R. W. Garnett of the University of Virginia Hospital have recently reported that they have used the enzyme to treat seventeen elderly patients who showed cerebral arterio-sclerosis and other symptoms of senility. They claim that it reduced the irritability and vagueness of the majority of the patients. The brain is particularly sensitive to lack of oxygen, and it may be that the administration of cytochrome C temporarily reduces the oxygen lack from which the brain cells are probably suffering as a result of the senile changes. Administration of cytochrome C has also been claimed to counteract the disturbing effect of oxygen lack upon the mental functions of pilots engaged in high altitude flights. The results of further research along these lines is awaited with interest.

* There are actually a number of cytochromes, and they are called cytochromes A, B and C. Cytochrome A is itself divided into cytochromes A_1 and A_2 and two types of cytochrome B are also known. Of all the cytochromes, however, we probably know most about cytochrome C. This is because it is the only soluble member of the group and can thus be removed and studied apart from the tissue. The other cytochromes are firmly attached to the tissue and, although methods have been devised for detaching them, little knowledge about them is yet available.

Ocean Waves and Storms

DURING the past hundred years or so many of the world's best mathematicians and theoretical physicists have investigated sea waves. And for a much longer period seamen have been acquiring a practical knowledge of how these waves behave. Yet till a few years ago there was very little connexion between the practical knowledge of the one and the theories of the other. All that was radically changed by the scientific preparation for the Allied invasion of Europe during the war. If a landing was to be a success it was essential to predict the state of the sea and beach surf from meteorological data; to preserve the element of surprise the landing craft must not come within sight of land unless good conditions were assured. Again, to make landing possible it was necessary to know how the beaches sloped; existing charts contained inadequate information, but it was found that beach slopes and depths could be estimated with sufficient accuracy by analysing aerial photographs of waves approaching the shore. To deal with these and other problems considerable research was carried out on sea waves and their behaviour. This research has been continued after the war and has radically changed our knowledge of the subject.

Until shortly before the invasion of Normandy the study of waves had been based almost entirely on visual observation, so that, for example, long low swell was easily lost among the more obvious waves produced by local winds. Then new methods of recording wave motion were introduced. One was an instrument which measures pressure fluctuations on the sea bottom some 40 to 100 ft. below the

waves and transmits the measurements to shore; from the pressure changes the wave heights can be calculated. Another method used an inverted echo sounder lying on the sea bottom and pointing upward to record an echo-profile of the waves.

The first result of these recordings was to emphasise what a complex mixture the waves are. It had long been suspected that the waves in natural conditions were formed from a superposition of many different wave components of different wave-lengths and velocities. It is also common observation that when a swell approaches a beach it gives alternately groups of high and low waves (it is not true, as common opinion has it, that every seventh wave is a high one); and it was believed that this phenomenon arose because the observed waves were a combination of several components which sometimes get into step and reinforce one another, sometimes out of step and partly neutralise one another. These general, but imprecise, observations were confirmed by the accurate records.

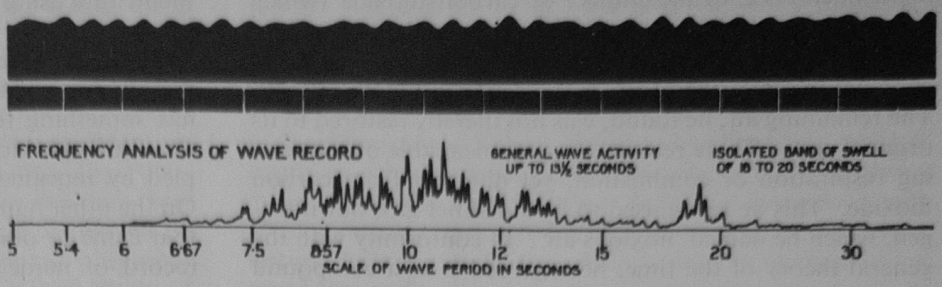


FIG. 1.—*Top:* part of a wave pressure record with 20-second time marks. *Bottom:* frequency analysis or wave spectrum of the record; the height of the wave indicates the intensity of the wave components having the corresponding frequency.
(Reproduced from The Quarterly Journal of the Royal Meteorological Society.)

In order to make further progress, it was necessary to analyse the waves observed into their various components, and a simple but ingenious apparatus was designed for doing so. In Fig. 1, the top curve shows a typical wave record, while the middle curve represents the 'wave-spectrum' obtained from it by the frequency analyser. The height of the curve at any point indicates the energy carried by waves of the corresponding frequency. (Owing to peculiarities of the apparatus, the individual peaks and troughs are of little significance; it is the general form of the curve that counts.) The waves actually observed at a given time and place are composed of wave trains having different wave-lengths and velocities and originating at different (and often very distant) places and different times. But usually these components can be separated, and the waves from any one storm clearly identified.

The waves from any given storm, however, do not arrive at the same time. This is because the velocity of water waves (unlike that of sound or light waves) depends on the wave-length—the longer the wave-length, the faster the rate of travel. Furthermore, the velocity with which a group of waves travel forward as a whole (its 'group velocity') is only half of the velocity of individual waves; all the time waves at the front of the group are dying out and new waves are rising behind. It is this group velocity that really matters, and investigation has shown that the group velocity in knots is approximately $1\frac{1}{2}$ times the period of the waves in seconds. For this reason, when swell from a distant storm is arriving it is the long-wave component that appears first.

Knowing the relation between speed of travel and wave-length, and knowing also the times at which the various components arrive and cease to arrive, one can calculate the distance of the storm in which the swell arose. And with the good North Atlantic meteorological service it was usually possible to identify the particular storm concerned. Hence, comparison of meteorological data with wave records, coupled with a great deal of other work on how waves behave as they come into shallow water, enabled methods to be built up for predicting from the weather reports just what would be the surf conditions on a given beach at a given time. This new power of prediction played a considerable part in the success of the invasion of Europe.

Looking for peace-time applications, it rather seems as if they will be in the reverse direction—a use of observed waves near a shore to give information about storms in distant parts. Observations at one station will tell how far away the storm is; two or more stations can locate it precisely. The wave records also reveal the wind strength in the storm of origin. Information obtained in this way will be several days late, since the waves travel slowly. And so, in regions where there are plenty of meteorological stations, it will be of very minor importance. But in the southern oceans, it may well provide valuable knowledge of storms that would otherwise go unobserved, and so may help to build up our general knowledge of the meteorology of these regions. A more immediately practical application arises from the fact that with the instruments available it is possible to detect the first very long swell from a distant storm while it is still so low as to be masked from the eye by local waves. This would give warning that a heavier swell is to be expected later. A harbour master in a southern port could thus be warned of a swell that would give bad conditions on the bar or in an exposed anchorage some twenty-four hours before the swell will actually arise and twelve hours before its approach could be detected by visual observation.

REFERENCES

G. E. R. Deacon: "Waves and Swell", *Quarterly Journal of the Royal Meteorological Society*, 1949, **75**, 227–38, which gives many other references.

G. E. R. Deacon: "Storm Warnings from Waves and Microseisms"; *Weather*, 1949, **4**, 74–9.

A symposium on ocean surface waves is to be found in the *Annals of the New York Academy of Sciences*, 1949, **51**, Art. 3, which contains contributions by eighteen scientists on this subject.

The Discoverer of Nitrogen

BETWEEN the work of Black and that of Lavoisier, the most important line of advance in chemistry was the study of gases. Thus anybody who discovered a new gas, especially one of the gases which later turned out to be elements, deserves a place in the roll of fame. One such was Daniel Rutherford, who was born on November 3, 1749.

Following up the work of his teacher, Joseph Black, Rutherford devoted his M.D. thesis at Edinburgh, dated

September 1772, to the subject of carbon dioxide (which he called 'fixed air' or 'mephitic air'). Producing carbon dioxide by the respiration of animals or the combustion of charcoal in atmospheric air, he absorbed it in a caustic lye. The remaining air, he found, was not thereby restored to its original state. There remained a gas, incapable of supporting respiration or combustion, yet different from carbon dioxide. This he recognised to be a distinct gas, our nitrogen, which he named 'noxious air'. In conformity with the general theory of the time, he regarded it as a compound of atmospheric air with phlogiston (the principle of inflammability which was supposed to be contained in all combustible substances). He further discovered that if sulphur, phosphorus or a metal were burned in atmospheric air only 'noxious air' and no 'mephitic air' was produced, thus making it clearer that these two are quite distinct.

In a paper read to the Royal Society six months before the publication of Rutherford's thesis, Joseph Priestley had anticipated most of Rutherford's experiments. He did not, however, draw any very clear conclusions from them, so that Rutherford (who fairly certainly did not know of Priestley's work) must have full credit for the discovery of nitrogen.

Having done this one brilliant investigation, Rutherford abandoned chemistry, becoming a medical man and a professor of botany at Edinburgh. He has, however, two other minor claims to fame—he was the uncle of Sir Walter Scott the poet and novelist, and he invented an improved maximum and minimum thermometer which is still described in many physics text-books today.

For the Absent Subscriber

In our April issue, page 129, we carried a description by Kurt Waltmann of an ingenious apparatus for recording telephone messages in the absence of the subscriber. A number of such devices have been developed and marketed recently and they appear to work well. But unfortunately their cost is too high for most people. There is, therefore, a good deal to be said for a recently invented device which gives the smaller, yet not unimportant, service of recording the telephone numbers of those who have rung during the subscriber's absence.

A caller who rings a number equipped with one of these devices will hear the ordinary ringing tone for fifteen seconds, and a bell will be sounding at the receiving end in the usual way. If nobody answers that call at the end of that time, the caller next hears for five seconds a special signal which informs him that a phone number recording device is in action. He now uses the ordinary telephone dial to dial his own number (or any number at which he wishes to be rung back), and the recording apparatus prints this number. When the absent subscriber comes home, he finds awaiting him a list of numbers at which his unsuccessful callers wish him to contact them.

The apparatus is compact—occupying only one-sixth of a cubic foot—and cheaper than message recording equipment. To instal it involves no change in equipment at the exchange or elsewhere, except for the connecting of the instrument to the receiver. Apart from the small printing mechanism it uses only standard parts. It works simply by accepting the series of 'pips' that are produced by dialling, amplifying them (using one valve), rearranging them and using them as signals to control the printing mechanism.

The device seems to promise obvious advantages from the point of view of caller and callee, and even the G.P.O. has something to gain from it, since it would reduce the time during which lines and exchange equipment are occupied by repeated attempts to reach an absent subscriber. On the other hand there may be something in one comment that came to our ears to the effect that one really needs a record of names as well as numbers, since there are so many people whom one wants to avoid calling back!

REFERENCE

F. Hinton and F. E. Planar: "A telephone number recorder", *Electrical Engineering*, Sept. 1949, pp. 795–6.

Forest Fires

Two phenomena resulting from the blazing summer of 1949 stand out. The first, which many who are not keen naturalists must have witnessed, was the effect of the long spell of hot weather on insect life-cycles; the ants, for instance, performed two marriage flights instead of the normal one.

The second phenomenon, a far more serious one, was the drought in the forests leading to the terrible fires which occurred in the Landes area of France. It prompts the question, can similar fires occur in Britain's new coniferous forests? It is something of a relief to find that in spite of the unprecedented dry spell, Britain's Forestry Commission can show a reduction of virtually 50% on last year's losses. To mid-September (the forest year ends on Sept. 30) about 1000 fires had been reported from Commission forests; the area burnt totalled some 470 acres, the number of trees lost was reckoned at 750,000, worth £20,000. Last year's figures were 1200 fires covering 1800 acres, while the two and three-quarter million trees lost cost us £45,000.

The better education and behaviour of the general public accounts for some of the improvement: a good omen for the future and let us hope an index of public behaviour in the National Parks to be. It should be noted that the total number of fires is slightly smaller than in 1948, but what has decreased enormously is the damage done by these fires. This is almost certainly due to the rapid improvement in scientific fire prevention and control, on the part of the authorities. Sixty-five-foot watch-towers in the major forests, the use of large-scale maps for rapid plotting, radio and field telephone for passing information quickly, are now commonplace weapons in the Commission's armoury. In the forest itself, water-tanks may be installed at strategic points; mobile tankers are also ready, while in some areas Bren-carriers have been prepared for use as fire-fighting vehicles.

Quite a different approach to the problem is that which might almost be termed the 'ecological'. It is only recently that the Commission has been able to spend large sums on the ploughing of fire-lanes through the forests themselves, and the widening of the rides between the stands. To the criticism that this wastes land which should be growing trees, the figure of a total expenditure this year of around £170,000 should be considered against the loss, in France, of £5 million, which it is now admitted was largely due to poor fire-prevention work in the past, and an inadequate control service at present.

The Inventor of the Valve

JOHN AMBROSE FLEMING, whose flash of genius turned the 'Edison effect' into the thermionic valve, should be remembered on the centenary of his birth—he was born on November 29, 1849, at Lancaster—for far more than that.

It so often happens that a man's name becomes perpetuated for one particular deed or discovery; that all he did in life—in a long span in the case of Fleming—becomes ignored or even forgotten, simply because one flash of inspiration, or even a lucky turn-up of the cards, provided something that eclipsed a long list of contributions to science.

Fleming might well have been lost to science when he turned schoolmaster at Cheltenham for three years. But this Lancaster parson's son, who had graduated from London's University College and the Royal College of Science, and then worked under Guthrie at South Kensington, took the wider view as once more he turned student when drawn to the Cavendish laboratory under the mantle of Clerk Maxwell.

Until well over 70 Ambrose Fleming proved himself in both the academic and more practical spheres. Like Sir Edward Appleton he went to St. John's, Cambridge, as scholar, later as Fellow, taking a first in natural science, becoming lecturer in mechanical sciences, and helping to plan the university engineering laboratories. Fleming returned to London as professor of electrical engineering after a year in the Nottingham chair of physics and mathematics. So we should remember that Fleming was ever a professor, ever the brains which the Edison Company could call upon, just as both London and the State could call upon him for expert advice. We see this eminent man as more than Marconi's fellow-worker, once we note results from this other side of his career. Soon after his London graduation his first published paper on the Contact Theory of the Galvanic Cell was good enough to be read as first paper presented before the foundation meeting of the new Physical Society. It proved a pointer to Fleming's lifelong work in the cause of electrical science.

Yet Fleming, the learned academic man on the one hand, became also the eminently practical man on the other. We now appreciate, since centenaries should be celebrated only by assessing in the light of today, how well he played his part in developing those three everyday boons: the electric lamp, the telephone and the radio. The London of seventy years ago saw things begin to move in applied electrical science because Fleming was there. First there were the rival Edison and Bell companies setting up telephone exchanges in defiance of any monopoly the Post Office might claim in view of the Telegraph Acts. These companies amalgamated later, had Fleming as scientific adviser in the Edison concern, and called him in along with Rayleigh and Kelvin to try and fight the State monopoly. Then Edison, the Edison who succeeded by sheer driving of himself and his men, had sent from America two electric lamps with those carbonised bamboo filaments chosen after he had scoured the world for suitable cellulosic material for filament-making. And Fleming was the man chosen to demonstrate these lamps connected to a battery of seventy dichromate cells (then known, of course, as 'bichromate cells').

In the birth of wireless Ambrose Fleming goes down in history's pages both as Marconi's associate and as father of the Thermionic Valve. He had visualised that wireless would be a boon at sea; he saw his belief a reality within a month when the East Goodwin lightship summoned help after a steamer had collided with it in a dense fog. In a lecture before the British Association he demonstrated trans-Channel wireless messages from Boulogne.

In December 1901, the first radio signals were sent across the Atlantic. The transmitter was sited at Poldhu in Cornwall, and for its design and performance tests Fleming was largely responsible. It was actually on December 12 that the delighted Marconi on the other side of the Atlantic first heard the signals sent out from Poldhu, signals he received on a kite-aerial 400 ft. high. But in all these growing-pains of wireless, Fleming was ever there with his theoretical basis. And we must remember too, his cymometer for measuring wave-lengths; his other work on loss in transformers, on high-tension A.C. transmission from Deptford to London, on the two-phase system in transmitting power from Niagara, together with his standard text-books on telegraphic and telephonic communication, on testing and measurement, on transformers and on wireless.

But then the sudden inspiration which brings perpetuation, the Fleming valve. Joule, Ampère, Volta, Watt and Faraday had all gone down in posterity's pages in units of measurement, in something more useful or fortunate than the perpetuation won by men like Silhouette, Guillotine or Quisling for example. Fleming began to think of some sort of 'valve', some device for passing current in one direction, thus enabling a telephone to be incorporated in wireless. Then, recalling the Edison effect he had pondered over about twenty years previously, with the blackening of bulbs in burnt-out lamps, he put his small metal plate connected to the positive, connected the filament to the negative, and the valve was born. He saw how with the plate connected to the antennae and a telephone in circuit, audible effects might be obtained in a receiver. Furthermore, the valve which was introduced for receiving purposes was to lead to valves as oscillators for transmission, this coming some years after Fleming had appreciated that Marconi's spark would have to be superseded by something more efficient in wireless communication.

The Fleming valve, which he improved with a metal cylinder for the plate, and increased sensitivity introduced with greater electronic emission, seemed soon to be overshadowed by Lee de Forest's further improvement with his 'grid' of fine wire interposed between plate and filament so that weak transmissions could be received. But Fleming's Oscillation Valve of 1904 still stands as a foundation, a base for all subsequent research, one which seemed to have doomed the crystal detector as rectifier even before this had been developed fully. American courts, it should be noted, laid down that de Forest's valve was merely a modification of Fleming's master patent. The valve has proved a progenitor of valves for reception and amplification, of valves which found so many other applications outside wireless.

M. SCHOFIELD.

2. *Lepiota procera.* The parasole mushroom. An inhabitant of thin woods and parklands, and one of the best of the esculents.

1. *Polyporus betulinus.* The birch polypore. Its large brackets are perhaps more often seen than those of any of the larger polypores.

3. *Boletus satanus.* A toadstool which has pores instead of gills.

Woodland Fungi

by

EXCEPT for the brilliance of the dying leaves, which may rival in beauty the crowded flowers of the spring woodlands, the autumnal activities of the smaller woodland plants are somewhat subtle in their interest, and for a full appreciation they demand more effort from the observer than do the wholly delightful scenes of April. Yet, in April, hidden growth is preparing the autumn show. Under the carpet of rotting leaves, in logs and stumps, beneath the bark of some of the trees and within the roots of the woody plants, moisture left from the winter and the growing warmth of the sun encourage the growth of the vegetative bodies of a host of fungi. These vegetative bodies, or mycelia, are systems of delicate branching threads, growing forward by the extension of their tips, producing branches which behave in the same way and permeating very thoroughly the organic debris left over from previous seasons by the woodland plants. Some of these threads enter the young roots as they spread a little beneath the surface of the soil, others spread in stumps and fallen wood. The mycelia, so far as we know, cannot compound the carbohydrates, fats and proteins they require for food, from simple inorganic material. That is a power special to the green plants, and it is they which produce the organic matter on which the mycelia draw. The living substance of the fungal threads, enclosed in a thin wall easily permeable to water, produces and secretes into their surroundings a variety of powerful enzymes. These convert some of the organic matter into water-soluble substances which diffuse in through the walls of the fungal threads, enter the living substance, and feed the fungus. Many woodland fungi cause these changes in the dead material among which the mycelia spread;

4. *Armillaria mucida*. The delicate, semi-transparent, whitish toadstools often add charm to decrepit beeches.

of the Autumn

B. BARNES, D.Sc., F.L.S.

these are saprophytes. Others enter and overcome the resistance set up by the cells of the living plants, killing the cells and maybe eventually the whole plant; these are parasites. Many others exist in a more complicated fashion. They use dead material, and they enter the living cells of other plants, where, however, the resistance of the cells to invasion prevents complete parasitism. Instead, a balanced condition is set up, a mycorrhizal association, in which both partners survive and from which, it appears, both get advantage. The fungus obtains carbohydrates from the higher plant, to which it transmits soluble nitrogenous supplies from the organic debris outside, supplies which would otherwise not be available to the higher plant. There seems no doubt that the mycorrhizal association is of the greatest importance to woodland trees, and that it enables them to maintain themselves on poor soils on which they could not survive without the co-operation of the fungal partner. Ultimately, this relationship must play a part in soil improvement.

But the mycorrhizal association is not as simple a matter as the foregoing brief explanation might suggest. It cannot be established between any kind of fungus and any kind of tree, nor do all fungi and all trees behave alike. Sometimes the possibilities of partnership are limited; thus, the handsome golden-yellow *Boletus elegans* is narrowly tied to larch, while the very showy fly agaric (*Amanita muscaria*) with its bright red cap flecked with white, not only associates freely with birch, but also with pines and spruces. The fly agaric is often depicted by artists who draw fanciful pictures of fairies. Its powerful intoxicating properties have long been known; on this

5. *Amanita muscaria*. The fly agaric. Common under birch where the bright red, white-flecked caps stand out conspicuously.

6. *Daedalea quercina*. A very common bracket fungus on old oak stumps, readily distinguished by its large, irregular pores.

7. (*Left*) *Calocera viscosa*. A bright red, somewhat gelatinous fructification not uncommon on dead pine wood.
8. (*Centre*) *Pholiota squarrosa*. A large toadstool, yellowish with brownish flecks, sometimes very conspicuous on stumps: it is said to prefer stumps of ash and apple.
9. (*Right*) *Xylaria hypoxylon*. The candle-snuff fungus. The branched fructifications may be found at the bases of stumps especially if the situation is somewhat sheltered. When young, vast numbers of spores whiten the upper parts of the branches of the fructification; after they have been dispersed the blackened branch ends look like extinguished candle wicks, and by this time a crop of a second kind of spores has developed inside cavities sunk in the branches. This fungus appears year after year on the same stump.

subject, Letter 32, in Oliver Goldsmith's *Citizen of the World*, will repay reading and give substance for meditation. The fly agaric has a common relative, the greenish-yellow death cap (*Amanita phalloidea*) one of the earliest toadstools to appear in thin woodland in suitable seasons, and by far the most dangerous of the few kinds of poisonous toadstools in this country. On the continent of Europe, dangerous cases of poisoning due to this fungus are of fairly common occurrence, and they have given much trouble to continental medical men. A few years ago, a very loathsome remedy consisting of the chopped brains and viscera of rabbits had some vogue as a treatment, but it was seldom that a patient could keep the dose down; very recent work has indicated that the injection of glucose together with free administration of saline drinks may provide a reliable means of coping with poisoning by the death cap.

Although much work has been done on the tree-fungus mycorrhiza, and although the difficult task of making the combination artificially has been successfully achieved in some instances, notably by the Swedish botanist, Melin, we are still very incompletely informed about the relationships between our common woodland trees and the numerous kinds of toadstools which regularly accompany them. The position is complicated by the circumstance that the same fungus may not behave in the same way all the time. A very common woodland toadstool, the honey agaric (*Armillaria mellea*) can live successfully as a saprophyte on stumps, but from these it spreads to the living roots and into the trunks of trees which are soon killed. In the soil, and under the bark of infected trees, the fungus spreads widely by means of its rhizomorphs, strands of aggregated threads resembling leather bootlaces, which stand up to drought better than do the isolated threads. The bootlaces are easily found forming a network beneath the cracking bark of recently killed trees. The honey agaric is equally effective as a parasite if it enters the tubers of potatoes, and yet there is a Japanese orchid, *Gastrodia elata*, which cannot flourish and fails to flower, unless its tubers are associated with the honey agaric. There are many other fungi that parasitise trees though few are such rapid killers as is the honey agaric. It has a relative, *Armillaria mucida*, whose delicate toadstools appear on beech. On healthy beech the fungus is not very destructive or even common, but trees in poor condition, and especially trees which are close to their altitudinal limit on mountain sides, may show severe attack. Stag headed oaks, that is oaks with one or more gaunt bare branches standing up above the leafy branches, are not uncommon. They are trees which harbour the relatively weakly parasitic beef-steak fungus (*Fistulina hepatica*) usually seated close to the base of the trunk. This fungus forms soft brackets which may weigh more than twenty pounds; they develop quickly, look rather like a piece of steak when cut, and have some reputation as esculents. The trees slowly degenerate, but sound timber from their trunks often has a fine brown colour, and is sometimes called lion oak. The soft, short-lived brackets of the beef-steak fungus contrast strongly with the resistant brackets of the birch polypore (*Polyporus betulinus*), a common and effective killer of birches, forming large brackets, which, when sliced, have been used as razor strops. Even more showy is a parasite of elms, *Polyporus squamosus*, with scales on the upper surface of the brackets. Dead branches of oak

10. (*Left*) *Cantharellus cibarius*. The chanterelle. A famous esculent often common in mixed woods, and occasionally so common that its yellow fruits simulate a bed of crocuses.
11. (*Centre*) *Clitocybe aurantiaca*. The false chanterelle. Often found with the chanterelle from which it differs in the thinner and broader gills. Not safe to eat.
12. (*Right*) *Phallus impudicus*. The stinkhorn. A fetid-smelling fructification much frequented by flies. It develops from an egg-like rudiment and in its final stages elongates very rapidly.

are often thickly occupied by the small yellow brackets of *Stereum hirsutum* which is apparently wholly saprophytic, but it has a common relative, *Stereum purpureum* with small purplish brackets often common on dead poplar trunks, and the cause of silver-leaf disease in plums, laburnums and other trees. The silvering of the leaf is caused by a substance which passes into the leaves in advance of the fungal threads, loosens the texture of the leaf, so admitting the air which effects the reflection of light and gives the characteristic aspect: the fungus is not present in the silvered leaves.

However diverse the nutritional habits of the woodland fungi, all need plenty of water if they are to grow strongly. So, as spring gives place to summer, it usually happens that the mycelia are checked in growth. Probably, during this period of restricted growth, physiological changes occur in the living substance of the mycelial threads which lead to the next stage. The onset of this stage, and the strength of its development, depend greatly on the weather in late summer and early autumn. At these times, temperature favours growth only if moisture is sufficient. In a warm wet summer, toadstools and brackets may be abundant by the end of August and very common by the middle of September. On the other hand, drought will greatly delay fruiting by the fungi, and may delay it so much that increasingly cold nights with ultimately, frost, may stop development before much fruiting has occurred. The autumn flush of fungi thus demands for its realisation a more delicately balanced set of weather conditions than is needed by the plants that flower in spring. They have reserves of stored food from the previous season and can grow rapidly on this as soon as the warmth is adequate: fungal mycelia normally have very little in reserve and consequently fruiting is much more conditioned by warmth and moisture.

In a suitable season, the mycelia which have slackened growth during the hotter part of the year resume activity, but now some of the threads elongate less and branch more, leading to the formation of dense pellets crowded with short threads. These pellets are the rudimentary fructifications, and, as they enlarge, the soil or the surface of the log is broken and the fructification is revealed. It is an exaggeration to say that a mushroom forms in a night, but the last stages of development are rapid, as they depend less upon new growth than upon the distension and expansion of parts already present in the nearly ripe fruit. In these last stages, the toadstools and brackets become very accurately adjusted so that their lower sides are horizontal, and so that the sticky young spores can fall freely downwards into the air below, where currents will waft them away. The spores are very small and light and are mostly transported by air; a noteworthy exception is provided by the foul-smelling stinkhorn (*Phallus impudicus*) where flies carry the spores.

Most of the fruit bodies are of one of two forms, either toadstools or brackets. The toadstool has a domed cap set on a central stem and with the spore-producing layer spread over 'gills', that is radial vertical plates which greatly increase the surface over which spores may be developed. Exceptionally, as in the genus *Boletus*, the fertile layer lines the surface of pits set vertically and visible at the lower surface as pores. The toadstool form predominates as the fruit of the fungi which inhabit litter on the floor of the wood, though toadstools also occur on stumps. More often, however, the fungi characteristic of stumps and logs have brackets, and although some brackets have gills, pores are much more common. There are also transitional conditions, toadstool organisations with their stalks placed to one side, and with gills or pores. A little reflection will suggest that the gill organisation should be better in a toadstool free to expand on all sides, while the pore organisation better fits a bracket which can spread only in one direction.

The fruit bodies differ greatly in their length of life. Those of some species last but a few days, others persist for some weeks, and still others are said to last for as much as eighty years, producing annual crops of spores. The number of spores produced is enormous, and the wastage must be equally gigantic. Liberation of the spores of a number of common fungi has been described in fascinating detail by the late Professor A. H. R. Buller in his *Researches on Fungi*.

It is paradoxical that the fungi possess the elaborate and elaborately adjusted fruit bodies and yet produce vast numbers of spores that have no future. On the whole, the spores of the forms which inhabit wood germinate fairly readily, and this may be related to the circumstance that a log does not last for a long time in damp woodland, so that colonisation of fresh pieces of wood is always necessary. On the other hand so long as there is no major change in the climate, those fungi which use fallen debris will have ever renewed supplies and, as their mycelia probably live for many years, the germination of the spores is not of great biological significance in survival, and it seems that the spores of these forms often do not germinate easily. It is puzzling to find elaborate devices which form and liberate vast numbers of spores which seem to be of little significance. But, as in all matters concerning living things, the subject is full of puzzles and it is that which makes most of the charm of his subject to the biologically minded person.

READING LIST

Readers who want to identify specimens of the larger fungi will find the following books useful: J. Ramsbottom, *Handbook of the Larger Fungi*, published by the Natural History Museum; E. W. Swanton, *Fungi and how to know them* (Methuen). A large part of the general text-book entitled *The Structure and Development of the Fungi* (H. C. I. Gwynne-Vaughan and B. Barnes, Cambridge University Press, 1937) is devoted to the larger fungi. Readers interested in the mechanisms of spore dispersal should consult *Spore Discharge in Land Plants* (Oxford University Press) by C. T. Ingold, who published a popular article on these mechanisms of fungi in DISCOVERY, October 1948 (pp. 314–19).

An Odd Bomb Story

MONTHS and months ago the story got around that a large number of photographic plates stored in New York had become fogged, and that this fogging could be directly linked with the explosion of the test atomic bomb in New Mexico. Now the full details have been published, and they add up to a most interesting story.

The story begins with the organisation in 1943 of an intensive paper salvage campaign. Soon afterwards the Eastman Kodak Company noticed that a good deal of their photographic material was getting fogged during storage. They investigated the trouble, and found that the fogging was due to the presence of minute amounts of radioactive material in the strawboard used for making the wrappings for the plates and films. The amount of radioactive material present was very small, but the radiation was sufficient to fog the plates and films after being in contact with them for several weeks. The nature of the radiation showed that the radioactive material was radium together with other elements naturally associated with it, and the source was finally traced to the self-luminous instrument dials, production of which had increased enormously owing to war-time demands. Many of these scales were printed on cardboard, and any defective ones were dutifully consigned to the paper salvage collector. Eventually, after repulping, particles of radioactive material found their way into the new strawboard supplied to Kodak.

In order to avoid this trouble Kodak arranged with a paper manufacturer at Vincennes, Indiana, to make special batches of strawboard for them in which no repulped material would be used. For some time all was well. On July 16, 1945, the first atomic bomb was exploded in New Mexico, and a few weeks later it was found that films wrapped in strawboard made on August 6 at Vincennes, *a thousand miles from New Mexico*, were badly fogged. At the time, of course, the news of the atomic explosion was still secret.

Careful tests showed that in this case the cause of the trouble was contamination with radioactive material which emitted beta particles, and it was realised that this was not a radioactive substance that occurred in nature. The amount of radioactive material was again very small, but by punching out the parts of the strawboard which had caused the fogged spots on the films it was concentrated sufficiently for chemical tests to be made on it. These showed that the radioactivity was associated with elements of the rare-earth group which must have originated in the fission cloud of the test explosion.

It remained to discover how the contamination was entering the strawboard. This was traced to the waters of the Wabash river, large quantities of which were used by the paper mill. It was found, moreover, that the incidence of fogging was increased when a batch of strawboard was made shortly after heavy rain had fallen in the catchment area of the river, so evidently the soil contained something radioactive which was washed into the river by rainwater.

Dr. J. H. Webb, of the Kodak Company who carried out the investigation was next able to connect the trouble with the atomic-bomb explosion (now no longer a secret) and he calculated that if 50 grams of radioactive cerium, a typical fission product, were formed in the explosion and this amount was spread over the whole area of the United States, there would be about 30,000 atoms per square millimetre. Allowing for local concentration of these atoms, as would occur during the manufacture of the strawboard, this quantity would be easily sufficient to produce the observed fogging. It is to be emphasised that the amounts of radioactive material involved are so small as to constitute no hazard to health. The accidental circumstances in which the effect was observed happened to be extremely favourable to the detection of such minute quantities.

Britain's Productive Efficiency

ARTHUR MARSH, M.A.

Is Britain's industry inefficient? In nineteenth-century Britain one doubts whether the question would ever have been asked, and even ten years ago it might have been regarded as rather academic. During the years between the wars, the formative period for most of the present features of Britain's industry, thinking people were occupied with other things, such as the effect on business and the country's employment and well-being of the recurrence of depressions like those of the early 1920's and 1930's. Industries that found themselves unable to compete in world markets were tending to 'blame the foreigner', 'sweated labour' abroad or economic circumstances in general for their misfortunes and to call for government protection and financial assistance rather than to make moves to put their own houses in order. Few people were anticipating that the state of efficiency of Britain's industry might in the future jeopardise the size of the national 'cake': most people were too busy attempting to safeguard their own economic positions.

Now, after the war, the situation is radically different. It is all too clear that with a reduced income from overseas investments and depleted gold reserves, the fate of our standard of living is more directly dependent than ever before on the amount of money which we can earn by selling the goods we produce to customers abroad, particularly those in the dollar area. We are roughly in the position of a man who lives almost entirely on the income he earns currently; we have used up almost all the savings which in more fortunate times we put away for a rainy day, and are living hand to mouth. We must therefore not only produce more if we can, but we must make sure that we can sell what we produce by ensuring that both the price and quality of our goods are what the consumer overseas will accept. It is not unnatural, therefore, that we should have suddenly become interested in what our minds and hands can do. Circumstances have forced us to become introspective about ourselves and our work, about our efficiency and costs of production and about the state and deficiencies of our industrial structure. Industry is polishing up its management technique; the Government is encouraging industrialists to see how the Americans do things through the operation of the Anglo-American Council on Productivity; it is investigating the various aspects of productive technique and incentives through the Tizard Committee; it is trying to stimulate backward industries to set up Development Councils—these are only a sample of the activity which is going on to find out more about our economic structure and to influence it to change to meet modern requirements.

The economist is in great demand in these operations. It is his job to formulate problems put to him, to analyse them, and to suggest remedies. He ought, therefore, to be in a position to produce evidence as to the condition of British industry, to confirm or deny that our industries are less efficient than those of the Americans, to tell us which industries are inefficient, and why this is so.

Unfortunately this is by no means as easy a task as it sounds. How do you compare the efficiency of two economies, two industries, or two firms? What is 'efficiency'? Even if 'efficiency' can be defined in a satisfactory way, is it possible to obtain the data necessary to work out comparisons? A great deal of work has been done on the answers to these questions, but even now the techniques of the measurement of economic efficiency have still to be perfected.

Comparing Efficiency

Theoretically, physical science ought to give a good clue to the problem of measurement. The efficiency of a piece of apparatus (for example, a heat engine), can be measured without ambiguity as useful output per unit of input. Surely this can be applied to the part of the economy with which we are most concerned—manufacturing industry? The so-called factors of production, labour, raw materials, capital and management, enter into a productive process and finished products come out. The factors themselves are not homogeneous, but both they and the final articles produced have a money value to which they can be reduced (i.e. cost of input or prime costs, and money value of output), and which it is possible to determine. Hence we ought to be able to estimate the comparative efficiency of an industrial unit by simple accounting—by working out its output per unit of input (on the principle that the firm which can produce most cheaply is most efficient), or, alternatively, costs of production per unit of output, a measurement which is useful where two firms are producing a very similar product.

Most economists would agree that this is a very useful way of arriving at efficiency comparisons, though most of them would also recognise that it is not perfect.* In using this method, a firm may seem to be more efficient because it pays lower wages, or because it is more favourably situated to obtain raw materials. Moreover, though a firm may be able to produce cheaply it is surely not efficient if it cannot sell what it produces! This argument is often quoted in support of the existing organisation of the British cotton industry. By re-deployment and re-equipment it could mass-produce and become more 'efficient' in the output-per-unit-of-input sense. But it might not then be able to sell its products if its customers insisted on the specialised textiles it formerly produced! But of all the problems of using this method of assessing efficiency the greatest is the difficulty of obtaining data, and the time and cost of collating it. Hence it has only been used so far where firms have been manufacturing very similar articles, and comparisons have been simplified.

It is not surprising, therefore, that most of the efficiency comparisons which we have between countries and industries are based on a simpler concept derived from data more

* Some economists argue that a great deal of harm has been done by considering efficiency purely in the terms described, and that it may sometimes be expensive to society (social costs such as smoke nuisances, bad labour conditions and so on). Though this is not directly relevant to the present discussion it ought not to be forgotten that economic efficiency can be unkind as well as kind to people, and that in the last resort it is people who matter.

COMPARISON BY PHYSICAL OUTPUT PER HEAD
(Index numbers, U.K. = 100)

Trade	*U.K.* 1935	*Germany* 1938	*United States* 1937
Radio sets	100	70	482
Motor cars	100	98	419
Iron and steel products	100	95	400 approx.
Blast furnace products	100	115	361
Machinery	100	110	280 approx.
Soap	100	117	279
Rubber tyres	100	117	266
Coal	100(1936)	143	263
Coke	100	152	221
Iron and steel foundries	100	120	186
Tobacco	100	30	171
Smelting and rolling iron and steel	100	114	168
Margarine	100	81	168
Boots and shoes	100	110	165
Breweries	100	67	164
Beet sugar	100	34	162
Rayon and silk	100	132	160
Wheat milling	100	93	160
Preserved food and vegetables	100	50	145
Hosiery	100	92	140
Cotton weaving	100	68	130
Cotton spinning	100	120	120

Adapted from Rostas, *Economic Journal* (1943).

COMPARISON BY VALUE OF OUTPUT PER HEAD
(Index numbers, U.K. = 100)

Trade	*U.K.* 1935	*Germany* 1936	*United States* 1937
Paper and printing	100	78	261
Engineering, motor and shipbuilding	100	126	254
Iron and steel	100	122	249
Clay and stone	100	82	247
Non-ferrous metals	100	142	227
Clothing	100	130	212
Textiles	100	129	200
Chemicals	100	106	186
Rubber	100	109	184
Leather	100	114	176
Timber	100	89	172
Food, drink and tobacco	100	86	156

Adapted from Rostas, *Economic Journal* (1943).

easily obtainable. This assumes that efficiency can be measured by calculating how much a unit of labour can produce in a unit of time, greater productivity being taken as an indication of greater efficiency. Popularly this method has become known as P.M.H. (production per man-hour).

The economist tries to estimate how much the average worker of a country, an industry or a firm produces in every hour of work he does, or sometimes in every shift which he puts in at his job.* Sometimes he finds it convenient to express P.M.H. in terms of physical output (e.g. so many radio sets per hour, if we assume that one radio set is nowadays very much like another); sometimes, when this is impossible, he has to do it in terms of value of output in, for example, £ or dollars; sometimes, when the problem of measurement becomes more complicated, he has to use index numbers or percentages, and say, for instance, that the P.M.H. of Firm *x* is 100 when that of Firm *y* is 120.

The chief recommendation of P.M.H. comparisons is that sufficient data does exist for countries and industries to make widespread comparisons possible. In this country, for example, it is possible to calculate output per head for any firm for any year. On the other hand, P.M.H. needs to be used with caution. If one country is shown to have a higher P.M.H. than another, implying that the amount of its equipment is higher per unit of labour, it does not *necessarily* follow that the second country is inefficient. Different economic environments, one would suppose, will produce between countries different levels of productivity, which in some cases can be accepted without undue concern. Corrections must be made for age and sex of the labour involved, since the assumption behind P.M.H. is that one unit of labour is exactly like another, and more corrections, if, for example, the hours worked in one country are different from those worked in another. Allowances have to be made for economic conditions. It would be unfair to state that because the O.M.S. in United Kingdom mines in 1938 was 1·148 tons as against the American 4·37 tons, American mines were four times as efficient as British. The natural conditions for coal-getting are so comparatively unfavourable in this country that the O.M.S. of 2 tons might be regarded as rather an achievement. In addition some of the objections to the output-per-unit-of-input method apply. No account is taken of social costs, or of the quality or saleability of the final product. P.M.H. is particularly difficult to handle when it appears as a net output by value over a period of time. The prices making up this output are certain to vary, sometimes so much that productivity comparisons along these lines are difficult to make with any precision and useless if not made with great care.

Much information is already available about P.M.H., in this country and outside. Professor Taussig, examining some British and American industries in the light of the Censuses of Production taken in 1907 (G.B.) and 1909 (U.S.) came to the conclusion that productivity per man in the United States was about twice that in the United Kingdom. This was broadly confirmed in other pre-war estimates done by Sir Alfred Flux and an Australian economist, Colin Clark. These efforts were rather limited in their scope, and it was not until 1943 that there appeared a comprehensive survey of three economies, the U.K., Germany and the U.S., based on their respective Censuses of Production for 1935, 1936 and 1937—an interesting sidelight on the time lag involved in the publication of government census figures. This survey was published at a time when the British and American economies were unusually closely connected, and experience of war-time production methods in the United States added to the force of the figures themselves.

Dr. Rostas arrived at his general estimate of relative productivities by calculating the value of net output for the three countries in the years concerned and dividing this by their respective working populations in manufacturing industry. From this it appeared that each worker

* In the latter case the expression used is not P.M.H., but O.M.S. —output per man-shift. This measure is used in industries which operate by the shift rather than by the hour. The coal industry is a good example of this.

in the U.K. and Germany produced about £240 worth of goods a year (the actual figures were £236 and £251 respectively), while in the United States the corresponding figure was between £379 and £510, an output per head probably twice as large. Even more interesting, however, he made productivity comparisons for individual industries based both on physical output per head (where industries produced similar goods), and on value of output per head where physical estimates were not possible. This he hoped would also act as a cross check if the results by both methods proved to be very much the same, which was indeed the case.

If one bears in mind the limitations of P.M.H. comparisons, the figures in the two accompanying tables speak for themselves. They have been arranged in order of superiority of American productivity.

In every recorded line of manufacture American productivity was apparently superior to British to a greater or less degree, while German productivity varied in comparison with British, being sometimes higher and sometimes lower. The Americans were particularly superior in producing radios and motor cars, iron and steel products, pig iron and machinery, and this superiority might have seemed even greater if differences in man-hours worked in the three countries had been taken into account.

Increases in Productivity

Strangely enough, there seemed to be no evidence that American superiority in productivity had increased since 1929. In fact, output per man-hour in the United States in 1938 was only 8% higher than in 1929, whereas in the U.K. and Germany it was 11% and 13% higher respectively.

But it must be remembered that before the war the U.S. were operating very much below full capacity, and with a high unemployment rate. If we regard P.M.H. as measuring *potential* productivity we must make a larger allowance for the States than for either the U.K. or Germany, and the productivity gap in actual fact might either have been uniformly wider or widening—probably the latter. In some industries we were clearly losing ground. Coal and cotton are the most outstanding examples. P.M.H. in no major coal-producing area in the world increased so slowly from 1913 onwards as it did in Britain. It was only 13% higher in 1938 than at the beginning of the First World War, whereas the United States's was 36%, Belgium's 40%, Germany's about 50%, Holland's 101%, and even France's 19% higher. A similar story can be told about cotton. The investigations of the Platt Cotton Textile Mission to the United States showed that in the thirty years from 1907 to 1937 productivity in the American cotton industry more than doubled while British productivity increased by only 46%. The productivity of our older industries was clearly lagging behind. It is more difficult to draw conclusions about the newer ones. Sir Stafford Cripps's industrial Working Parties, which often made P.M.H. comparisons with the United States in their reports, tended to tell the same story of increasing or continuing backwardness but again these industries were selected because they were known to need attention. Even the newer industries like radio manufacturing, motor cars, rubber and rayon do not show up well in Dr. Rostas's findings, though it is quite possible that they have made a good deal of headway since the last census of production was taken in 1935. Productivity is known to have increased quite sharply in some of our industries, such as cement.

A later article will examine the possible causes of productivity discrepancies and indicate the rôle of science in narrowing them. Meanwhile, what are we to say in general about the efficiency of British industry?

Most economists have concluded that the situation looks rather black, but have been shrewd enough to reserve their judgment. The fact that P.M.H., our most readily available measure of comparison, is not unambiguous makes it difficult to be objective and easy to excuse industries on special grounds (as we have already half excused the coal and cotton industries above). In addition some people have been only too ready to point out that despite apparent differences in productive efficiency between Great Britain and the United States there is no reason to suppose that real income per head (i.e. income per head of the population in terms of what it will buy—an index of economic welfare), was significantly lower on this side of the Atlantic than on the other before the war. and that, therefore, P.M.H. comparisons must have missed the point and failed to discover where Britain's real efficiencies lie.

Both these are without doubt valid criticisms of what the economist has been able to do so far in reviewing the efficiency of this country's industry. On the other hand, they are not necessarily relevant to the present economic situation. They tend to assume that we have time to sit back until the economist perfects his definitions and methods and until we can prove that deficiencies in our industry are affecting the level of real income. Surely this assumption is untrue? *Surely it is sufficiently clear that with British industry in its present condition real income per head cannot be maintained?* The fact is that we live by exports and that our exports are not sufficiently competitive to hold the world's markets. We cannot escape this fact by explaining away the deficiencies of our industries on the grounds that they are a series of special cases; nor can we afford to ignore the warnings of those who have produced comparisons of productivity, however cautious we might like to be in applying them. It may pay to assume that available data does not exaggerate the inefficiency of British industry, provided that this leads to progress in improving the situation into which we seem to be slipping —that of becoming exporters of hand-made curiosities to dollar purchasers with sufficiently high incomes to despise standardised products.

(This is the first of two articles by Mr. Marsh dealing with aspects of productivity. In the next issue Mr. Marsh will discuss why American productivity is higher in general than British productivity, what can be done to improve the situation and the contribution the Scientist has to make in this connexion.)

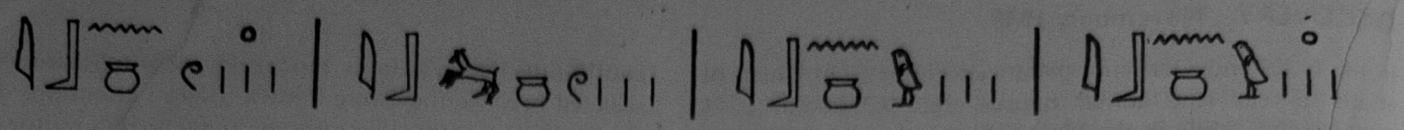


FIG. 1.—Four Egyptian hieroglyphs for alum. The one on the left comes from the Ebers Papyrus (about 1550 B.C.).

The Story of Alum

S. LILLEY, M.Sc., Ph.D.

IF by a chemical industry we mean simply any industry based on what we now recognise as chemical reactions, then the alum industry is far from the oldest—pottery beats it by several thousand years, cookery (if that can be called an industry) by perhaps half a million. But if we refer to industries that produce chemically pure substances, and substances, moreover, whose value depends on their purity, then alum production is by far the oldest chemical industry.* In fact, it was virtually the *only* chemical industry till nearly modern times. Alum was the only substance, except possibly gold, which the ancients could produce in anything like a pure state.

Though alum has many uses, it was mainly its rôle in dyeing that made it industrially important. Among the advantages of modern synthetic dyes is the fact that they give good results when applied directly to the textile without any intermediary. But most of the natural dyes, on which all dyeing depended till less than a century ago, give poor colours and fade quickly unless the textile is previously treated with one of a class of substances known as mordants. The mordant acts as a link between fibre and dye, and so enables faster and brighter colours to be obtained. Till fairly recent times alum was almost the only mordant. But the value of alum as a mordant depends very greatly on its purity; quite small contaminations with soluble coloured salts of iron reduce enormously the quality of the result. And alum, like most naturally occurring substances, is usually contaminated with iron. But it has a unique combination of properties that made it possible to free it from impurities even with the crude techniques of four thousand years ago. It is more than twenty times as soluble in boiling as in cold water and it crystallises in large and easily distinguishable crystals, so that the quite elementary process of making a saturated hot solution, allowing it to cool, picking out and washing the abundant crystals, permits remarkably pure specimens to be obtained. The fact that its crystals are colourless while the more important impurities are strongly coloured gives a convenient practical test of purity.

Analysis of ancient materials shows that alum has been used as a mordant for at least 4000 years, and more general and speculative arguments would suggest that this use may date back to about 3000 B.C. For at least 2000 years it has been used to make hides more durable and supple. For 1500 years or so it has been used to make parchment more durable and more receptive to ink. For some 600 years it has been similarly applied to the improvement of paper. For some centuries it has been used to purify water by flocculation. In Mesopotamia in classical times, and often since, it was used for the fire-proofing of wood and textiles (here, however, its chemical properties are not involved but only its solubility and large content of water of crystallisation). It was prescribed for a wide variety of medical purposes 3500 years ago and often since, though, apart from its astringent properties, it is medically useless. In fact—as often happens to a really useful material—alum acquired a vast number of spurious uses besides its genuine ones.

Native Alum

Alum is found native in various places, for instance, in Egyptian oases. Presumably the early industry was based on the gathering and purification of native alum, though in fact very little is known of production processes before medieval times. The earliest direct evidence of its use is a fragment of Egyptian leather dating from about 2000 B.C., dyed in a way that suggests an alum mordant. The first known literary reference is in the Ebers Papyrus of about 1550 B.C., but the material in this work is derived from other lost documents and from a tradition which certainly reach back into at least the third millenium B.C.

In the Greek 'alchemical' writings—a misnomer since they are mainly technological chemical works without taint of alchemy in the usual sense of the word—references to uses of alum frequently occur, for example, in various recipes for producing gilt and silver colouring. The balance of evidence suggests that the technological knowledge here recorded is derived from—indeed is a rather inferior copy of—Mesopotamian and especially Egyptian practice. Highly valued in classical times was the famous Tyrian purple dye, made from *murex* whelks. Eight thousand whelks yield about a gram of the dye. The dye of the aristocrat, in Byzantium its name became synonymous with 'Imperial'. It was enormously costly, its price being equivalent to £2500 per kilogram. Here obviously was a great temptation for imitators. The genuine dye requires no mordant, but imitations do. And so the Greek 'alchemical' writings contain recipes for spurious purples, involving the use of alum. There is evidence that the production of spurious purples eventually became a considerable industry.

Several of the classical scientific writers make mention of alum. A lost work of Theophrastus (372–287 B.C., the successor of Aristotle, best known for his botanical work)

* This article is based on Dr. Charles Singer's, *The Earliest Chemical Industry* (London, The Folio Society, 1948; £10 10*s*. or £26 5*s*.), publication of which is an important event in the annals of the history of science.

was entitled *On salt, soda and alum*. Alum was often mentioned in medical works and was described with some accuracy by Dioscorides (first century A.D.). But, of course, Greek science never got far enough even to begin to understand its chemical nature. Among the Romans, the elder Pliny (A.D. 23–79) had much to say on the subject, but under the general term 'alum' he confused many substances only slightly related to one another. He described a method of testing the purity, using "pomegranate juice, which does not darken the alumen if the latter be pure"; this is in fact a test for iron contaminations which would form ink with the tannins in the juice.

Contrary to common belief the Middle Ages were a time of great technical progress, and in that period the industrial potentialities of alum were vastly increased by the discovery of methods of manufacturing it from other and commoner minerals. To explain these developments it is necessary to say a few words on the chemistry of the alums, although, of course, this was not understood till after the rise of modern chemical science. 'Alum' is a generic term used to cover a group of substances with very similar properties. These are all double sulphates of aluminium and one of the alkali metals or ammonium. Thus potash alum is $KAl(SO_4)_2$, $12H_2O$ and ammonium alum is $NH_4Al(SO_4)_2, 12H_2O$. Potash alum was the first of the alums to become important, since it is by far the commonest in nature, and also probably the first to be manufactured from other materials. About the tenth century it was discovered that potassium alum could be manufactured from the mineral *alunite*, a basic potassium aluminium sulphate, $KAl(SO_4)_2, Al_2O_3, 4H_2O$. Alunite contains all the elements of potassium alum, but with an excess of alumina (aluminium oxide, Al_2O_3). Alum is prepared from it by roasting, weathering (for work on an industrial scale) and extracting with water, followed by the usual purification by crystallisation. This method was being used in Italy not later than the thirteenth century, as is shown by a brief reference to it in an alchemical manuscript of that time.

Alunite, though much commoner than native alum, is found in comparatively few places (mainly in volcanic regions). But in the Near East in the earlier Middle Ages a further important step was taken with the discovery of how to produce alum from the much commoner rocks containing aluminium sulphate. Ammonium alum was produced from this by the addition of stale urine, which contains ammonia. This method on a laboratory scale is described in a translation, dated about 1170, by Gerard of Cremona from a Spanish Arab alchemical text of about 1100. Its serious use as an industrial process, at least in Europe, belongs to the next two or three centuries.

Alum in Medieval Trade

Alum was one of the more important items of medieval trade. Many interesting records of it have survived, though there is not the space to discuss them here. It was, for instance, one of the main articles of trade in some of the northern French fairs. Most of it came from the East, and it formed an important item in the East–West carrier trade that was responsible for so much of Italy's medieval greatness. Alum was apparently not imported into Britain before the Conquest or even for some time afterwards; we begin to hear of it about the end of the twelfth century. The cost of alum varied enormously with time and place. Sometimes it was so valuable as to be classed among the spices for trading purposes; this happened at Venice in 1233 and at Florence in the later fourteenth century.

About the middle of the fifteenth century great changes were taking place in Europe. A long process of technological and economic progress and a rapid increase in trade and industry had created great new accumulations of wealth, especially in the commercial cities of Italy, Flanders and elsewhere. The textile industries were advancing rapidly and were the staple trade of such towns as Florence; the demand for alum as a mordant increased. The new industry of printing increased the need for alum in paper-making. And in general the new wealth widened the market for many types of goods involving the use of alum.

At the same time the advance of the Turks dislocated the eastern alum trade, and cut off almost completely some of the main sources. The increased demand and the failure of the former sources of supply led to a great hunger for alum in Europe, a hunger that had many consequences. It had economic consequences, since the search for alternative supplies led to the creation of new industries and new industrial districts; it had technological consequences, because outside some specially favoured centres the new supplies could only be obtained by the development of new methods; there were political consequences, too, and even religious consequences, alum politics playing a part in the events which led to the Reformation.

A quarrel over newly discovered sources of alunite led to a war between Florence and Volterra in 1472. And the whole story of alum in the next century or so is so soiled with political and commercial intrigue as to produce a marked contrast between the purity of the alum and the impurity of the trade.

Alum and the Crusades

In 1461 a certain Giovanni de Castro discovered large quantities of alunite at Tolfa in papal territory. He reported his discovery to Pope Pius II in terms which contained a judicious mixture of religious, political and economic appeal: "I announce to you a victory over the Turk. He draws yearly from the Christians above three hundred thousand gold pieces for the alum with which we dye our wool. . . . I have, however, found seven hills so stocked with alum as to be nigh sufficient for seven worlds. From them you may supply all Europe. . . . What used to be gain to the Turk, being in your hands will thus be to him a double loss. . . . This mineral will give you the sinews of war, which is money, the while it takes them from the Turk." After some hesitation the Pope decided to exploit the Tolfa mines, and by 1463 some 8000 workmen were employed there.

The alum revenue was assigned to *La Crociata*, the fund for financing a proposed crusade against the Turk. Here religious motives were intricately interwoven with power politics. As the hopes of a crusade faded, the fund was used instead to subsidise defence, to relieve refugees and to aid enemies of the Turkish rulers. For example, in 1465 Hungary, the country most threatened by the Turk, was given a grant of 57,500 ducats, and smaller sums followed at intervals.

In order to strengthen the financial yield from Tolfa,

successive Popes sought to prohibit the faithful from using alum derived from Turkish sources. At first they did no more than 'adjure and demand' Christians not to buy from the Turk. But soon they used heavier artillery. In 1465 it was decreed that all who bought alum from the Infidel should "be subject ipso facto to Excommunication, Anathema and perpetual Malediction by Almighty God, Father, Son and Holy Ghost". An Encyclical of 1506 (incidentally the first Encyclical to be printed) used similar threats even more forcibly and offered "Plenary Remission and Indulgence" to all by whose act Infidel alum was destroyed.

Not only was Turkish alum thus frowned upon, but attempts were repeatedly made to establish a full papal monopoly, excluding all other producers. The methods used closely resemble those of present-day cartels. At a time when the demand for alum was rising and when its production was on the increase in many places this was bound to lead to conflicts; and many were the quarrels that centred round the papal claims to alum monopoly. These formed a not unimportant part of the major conflict of the time—the attempt of the rising commercial states of the north to break free from the general economic and political dominance of the papacy and of those states which believed they could control the papacy. It was this struggle which provided the political background to, and indeed foundation of, the Reformation. To say this is not to deny the genuinely religious urges of the Reformers, but merely to recognise that if there had not been political and economic antagonism between the German and English princes or the rulers of Swiss states on the one hand and the papal power on the other, then the Reformers would have remained ineffective though heroic idealists, like so many of their predecessors, instead of receiving the influential support and mass backing which turned them into leaders of a Reformation that split Europe in two. Alum, with its attempted papal monopoly, was, as we have said, one of the elements in this general economic conflict. And it is no accident that alum had a prominent place in the historic Indulgence which led Luther in 1517 to nail his famous 95 Theses on the church door at Wittenburg. This granted "plenary indulgence one in a lifetime or at impending death" to all who gave money for the repair of St. Peter's at Rome for all sins and censures "excepting only conspiracy against the Pontiff's person, murder of Bishops or other superior Prelates, physical violence to Bishops or other Prelates, forgery of Apostolic letters, export of arms or prohibited goods to the Infidels, and, as regards censures those related to the alum of Apostolic Tolfa and involved in the import [of alum] from the lands of the Infidels to those of Believers, contrary to Apostolic prohibition".

The Reformation naturally destroyed all semblance of a papal monopoly, though as a matter of fact Tolfa alum remained important for a long time because of its high quality. Threats of excommunication for buying Turkish alum ceased about 1578, though attempts were made to maintain an alum cartel by ordinary business methods. But never again was alum to be the object of intrigue and the cause of war and religious revolution that it had been in the fifty years or so before the Reformation.

Manufacture from Shale

The fifteenth-century alum famine, accentuated by the papal monopoly, brought into industrial prominence a new method of alum manufacture from yet more widely available mineral resources, namely aluminous shales. These are shales containing a high proportion of alumina (aluminium oxide) and iron pyrites (iron disulphide). When they are roasted in air the pyrites yields ferrous sulphate and sulphuric acid, and these in turn react with the alumina to give aluminium sulphate. This is extracted with water and transformed into alum by an alkali (from urine, kelp ashes or wood ashes). The iron salts and remaining aluminium sulphate are then removed by solution and crystallisation, using the fact that they are more soluble than the alum.

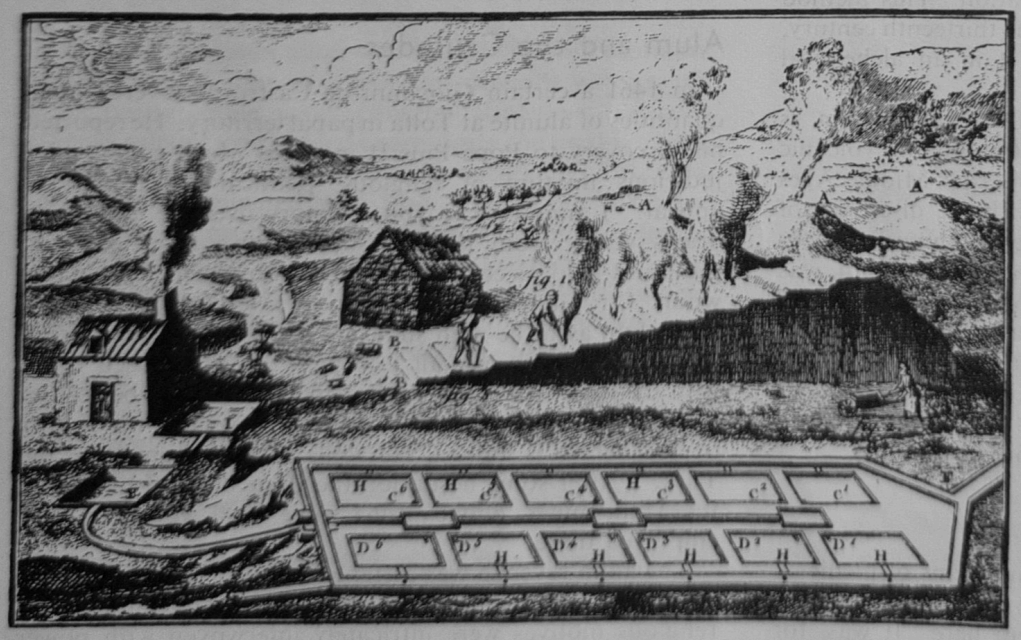


FIG. 2.—An alum factory near Liège. This picture is taken from Diderot's Encyclopedia (1768). The alum ore was piled up in heaps (AAA) and left to weather for two years, often igniting spontaneously in the process. Alternate layers of weathered ore and brushwood were then piled in a terraced heap and fired; after roasting, the mineral was barrowed into tanks (C1–C6), water added and the resulting solution transferred to the three small settling tanks in the centre. The clear liquor was then run into the reservoirs F and I, next to boiling house on left, and transferred to cauldrons for concentration by boiling.

The origins of this process are still shrouded in mystery. Alum had been made from shale in the laboratory in the thirteenth century, and the method possibly derives from the eastern alchemists. There is, however, no good evidence of its use in the Orient on an industrial scale, and it is very likely that the western practice derives from an independent discovery. From hints in the late fifteenth-century literature it would seem that the method had long been used industrially in a few localities in the West as a secret process. But the essential fact is that the shale method became industrially

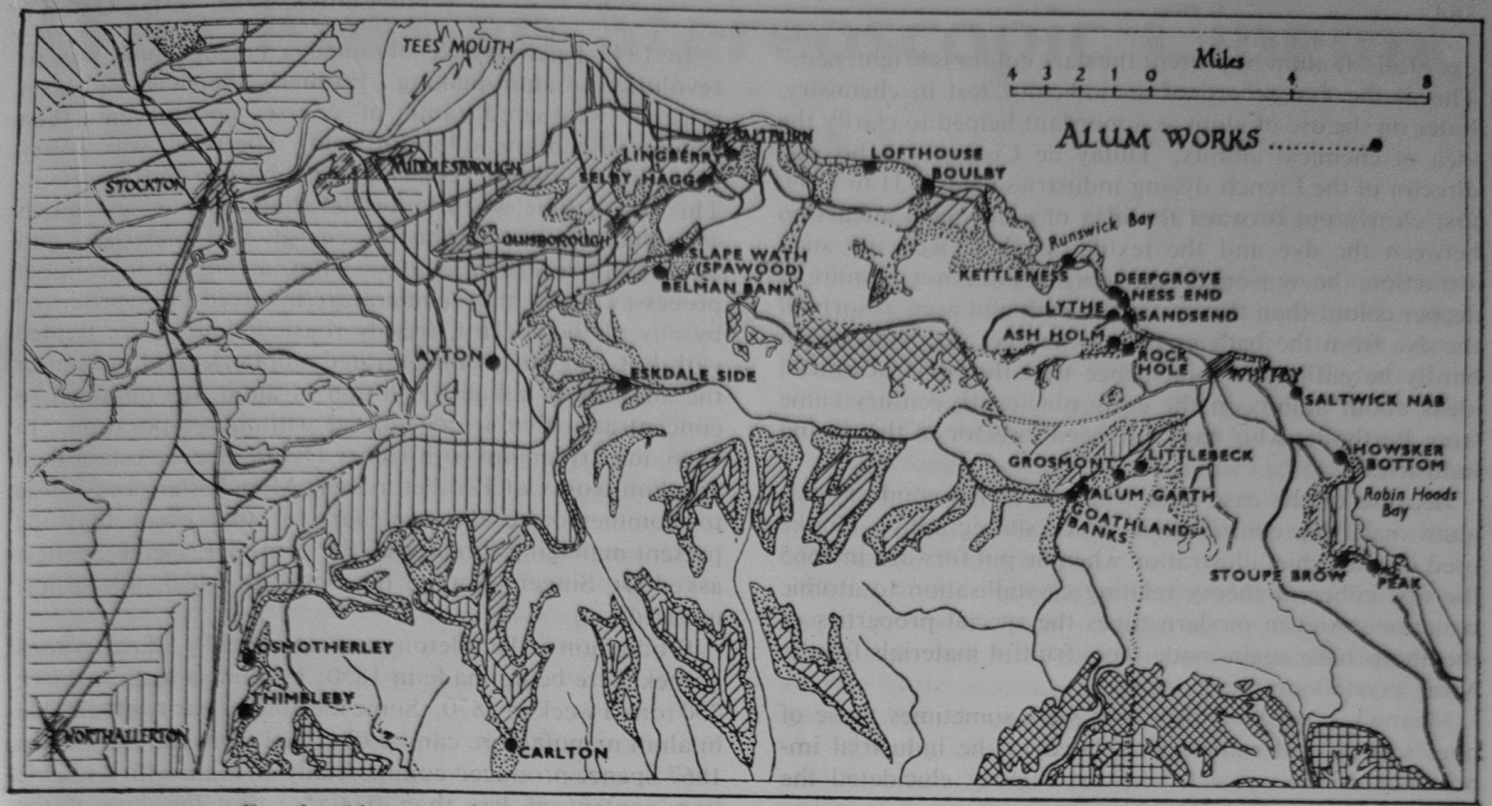


FIG. 3.—Alum manufacture from Yorkshire shales started in the early seventeenth century. This map shows how alum factories in N.E. Yorkshire were located on the geological formation known as the Upper Lias; the dotted areas represent the exposure of that formation.

important in Europe in the latter part of the fifteenth century, and that thenceforward it revolutionised the industry.

Alum manufacture now spread rapidly over many parts of Europe, for suitable shales are widely distributed. England was comparatively late in the field. A series of attempts were made to start alum production here from 1545 onwards, but it was not till the early seventeenth century that the Chaloner family were successful in producing alum commercially from the shales of Yorkshire. These works naturally aroused the interest of the early members of the Royal Society, and the first description of the process in England was given by Daniel Colwall, a patron of the Society, in the *Philosophical Transactions* for 1678. Working of the Yorkshire shales continued till near the end of the nineteenth century and produced, besides alum, a large palæontological by-product in the form of fossil ammonites, ichthyosauri, pleiosauri and pterodactyls, which for long served to stock the museums of the world.

Requiring the addition of an alkali from outside, the shale process actually turned the collection and supply of urine into a regular industry, but the position changed when ammonia became available as a coal-gas by-product.

One alum area in the Saar had interesting literary associations. A coal-mine near the village of Duttweiler caught fire in 1688, and during attempts to extinguish it alum shale was discovered in the upper strata. In 1691 alum works were started there, and continued with varying fortunes till 1840. The underground fire did the roasting process free, so that only the subsequent lixiviation and purification was necessary. Goethe visited these works in 1771 and commented that here "I gained my first glimpse of the absorbing interest of economic and technical developments and this has since been much with me".

In the sixteenth century we enter the era of modern science. Before then our technical information on alum is derived partly from proto-sciences like alchemy, but chiefly from the working handbooks of craftsmen. Much that we should like to know is missing from the latter, for craft secrecy was strong and in any case the handbooks were often in the nature of *memoria technica* for the benefit of those already skilled rather than full descriptions for the uninitiated. But in the sixteenth century a number of writers began to describe technical processes, alum-making included, fully and with much of the scientific spirit. An important description occurs, for example, in Biringuccio's *Pirotechnia* (1540). About the same time came the beginnings of scientific mineralogy. On the one hand some were drawn to study minerals for their economic importance, and on the other, the virtuosi collected cabinets of minerals for the sheer love of collecting, sometimes with no more system than magpies but sometimes very skilfully. Men like Aldrovani (1522–1607) and Cesalpino (1519–1603) began to evolve systematic methods of describing and classifying minerals. In all these efforts alum, because of its clear and definite crystalline form, as well as its practical importance, took a prominent place.

From this time on it is possible to trace how growing science helped to improve the alum industry and industries like dyeing associated with it. And, on the other hand, we can see alum itself playing a fundamental part in the advance of science—partly because the economic importance of alum inevitably drew the attention of scientists to it, partly because the very special properties of the substance made it attractive to the scientist and specially suitable for the advancing of fundamental knowledge.

As a simple and early example of alum contributing to the advance of scientific chemistry we can instance a test given in 1556 by Gabriele Fallopia for the presence of alum in solution: "Evaporate till a sediment forms. Add now a decoction of galls or an infusion of brasil wood or other

dye-stuff. If alum be present the dark colour is brightened." This is the first record of an indicator test in chemistry. Later on the use of alum as a mordant helped to clarify the idea of chemical affinity. Dufay de Cisternay, who was director of the French dyeing industries from 1731 to 1739, first clearly put forward the idea of a chemical attraction between the dye and the textile—if there were no such attraction, he reasoned, the fibres could not acquire a deeper colour than the dye in the bath and even absorb all the dye from the bath as they sometimes do. And it can hardly be entirely a coincidence that the most advanced ideas about affinity in the early nineteenth century came from Berthollet who had also been director of the dyeing industries.

Because of the ease with which it forms good crystals alum made big contributions to crystallography. Hooke used it as his chief illustration when he put forward in 1665 the first coherent theory relating crystallisation to atomic structure. And in modern times the special properties of the alums have again made them fruitful materials for the X-ray crystallographers.

Meanwhile, with motives that were sometimes those of pure science and sometimes related to the industrial importance of the subject, scientists slowly elucidated the chemical nature of alum.

Attempts to apply science to the improvement of dyeing date from the seventeenth century. So important a subject naturally attracted the attention of scientists who were interested in applications of their work, and in the early days of the Royal Society the influence of Sir William Petty (1623–87) made it specially popular. Petty himself was one of the first to get a clear idea of the action of alum as a mordant; he concluded that "Alum is a Vinculum between Cloth and Colour". During the eighteenth century almost all the advances in scientific dyeing were made in France. Dufay (1698–1739), for example, introduced exact methods for estimating the effectiveness of dye-stuffs and mordants. Hellot (1685–1766), Macquer (1718–84) and, above all, Berthollet (1748–1822) worked to turn the trade from a rule-of-thumb craft into a scientific industry. At the end of the century Bancroft (1744–1818), making several practical advances and writing his famous *Experimental Researches Concerning the Philosophy of Permanent Colours* (1794 and 1813), put England once more on the map. But we cannot follow further the history of scientific dyeing.

In 1845 Peter Spence obtained a patent which was to revolutionise alum-making. Formerly the shale had been roasted, weathered (and, of course, cooled) and then treated with dilute sulphuric acid. The result was a very dilute alum solution requiring much heat to concentrate it. This was a time when industrial thinking was very much concerned with economy of energy and materials, and Spence applied such ideas to alum, arranging to conduct processes at the high temperature involved in or produced by any of them. Hot, freshly roasted shales were treated with hot and fairly concentrated sulphuric acid, and after the addition of alkali a solution of alum was obtained so concentrated that it crystallised without evaporation. In 1846, in partnership with Henry Dixon, Spence established an alum works at Pendleton near Manchester, and it was to commemorate the centenary of that event that the present managing director of the firm, Mr. Derek Spence, asked Dr. Singer to write the book on which this article is based.

Production at Pendleton increased rapidly. Twenty tons a week were being made in 1850; 110 tons a week in 1860; 250 tons a week in 1870. Some idea of the purity obtainable in alum manufacture can be obtained from the fact that in 1867 Spence produced commercially an alum with a soluble iron content of less than 0·005%. But the days of the uniqueness of alum were nearly over. The new synthetic dyes that followed rapidly on Perkin's discovery of synthetic mauve in 1858 do not require mordants. After about 1880 natural dyes rapidly went out of use and with them went the main demand for alum. For most other uses to which alum had formerly been put aluminium sulphate is just as good; indeed this is true even for its use as a mordant—alum itself had been necessary before only because it could be produced pure with crude techniques, whereas aluminium sulphate could not. With improvements of chemical techniques aluminium sulphate could replace alum for almost every purpose, and so in the last quarter of the nineteenth century the alum industry declined and gave place to aluminium sulphate.

Alum will never again be of major industrial importance. But if it had a soul it could look back on an exciting life in which its activities have ranged from giving men handsome clothes and teaching scientists the first steps in crystallography to provoking wars and helping to establish new religions.

FIG. 4.—A group of evaporators at the Hurlet alum works in Renfrewshire, about 1835.

The Russian Stereoscopic Cinema

DENIS SEGALLER, B.Sc.

IT is almost a commonplace—as anyone will know who has been rendered temporarily one-eyed by having to wear an eye-shade—that we judge depths and distances away from us by correlating the sensations of our two eyes. The left eye sees things at a slightly different angle from the right, and the brain is thus presented with two slightly different images of the objects within the field of vision. The combination of the two images gives us the 'feeling' of depth. No doubt those who are unfortunate enough to be permanently one-eyed adapt themselves and learn in time to judge distances by other criteria based on experience or perhaps a kind of half-instinctive calculation; but to the person with normal sight the feeling of 'three-dimensionalness' is primarily the consequence of binocular vision; hence when temporarily one-eyed he misses this 'sense' of depth and even lighting a cigarette can become an acute embarrassment.

Clearly, any *simple* two-dimensional representation of the three-dimensional world such as an ordinary photograph or a painting cannot produce this feeling of depth since it presents to both eyes an identical image of the objects depicted. In order to reproduce the feeling of depth by means of two-dimensional images the basic rule governing all methods of recording and reproducing physical sensations must be obeyed: the recording and reproducing apparatus must imitate the sensory apparatus of the body which produces that sensation in the brain. In other words, to make stereoscopic pictures we must first record and reproduce the two separate images seen by the left and right eyes respectively, and then view these images in such a way that the left eye sees *only* the left eye reproduction and the right eye only the right eye reproduction. The brain will then fuse these two reproduced images and a sensation of depth will have been achieved with two-dimensional reproductions.

These basic facts of stereoscopy were known long before photography itself—in fact a pair of hand-drawn images dated 1650 is known. But their application to the cinema has been a much more difficult matter. Obviously the simple stereoscope is out of the question, since each member of the audience would need his own private projector and screen—quite apart from the fact that few would care to sit for an hour and a half at a stretch with their eyes glued to a stereoscope, even for the sake of a three-dimensional Betty Grable.

For a similar reason two practical systems for stereoscopic motion pictures needing no special projector or screen have had but limited use—they both require the wearing by the audience of special spectacles. One of these systems depends on separating the two images by polarised light, the other on image separation by colour filters.

In Russia a different approach has been made, and the system of *Raster Stereoscopy* evolved.* This is based on the principle of separating the two images, not at the viewer's eyes with the aid of *individual* appliances such as spectacles, but at the screen by a *device common to all viewers*. In essence the principle is identical with that of the so-called static 'Deep Pictures' described in DISCOVERY ("Stereoscopy by a new Method", Vol. VIII, No. 10, October 1947, p. 293). Examples of this technique are at present on display at many station bookstalls.

The idea of separating the images in the immediate neighbourhood of the screen by a common device was put forward at the end of the last century. It was proposed for

* Details of this system of Raster-Cinestereoscopy are taken from an article by B. T. Ivanov in *Nauka I Zhizn* (1947, No. 8).

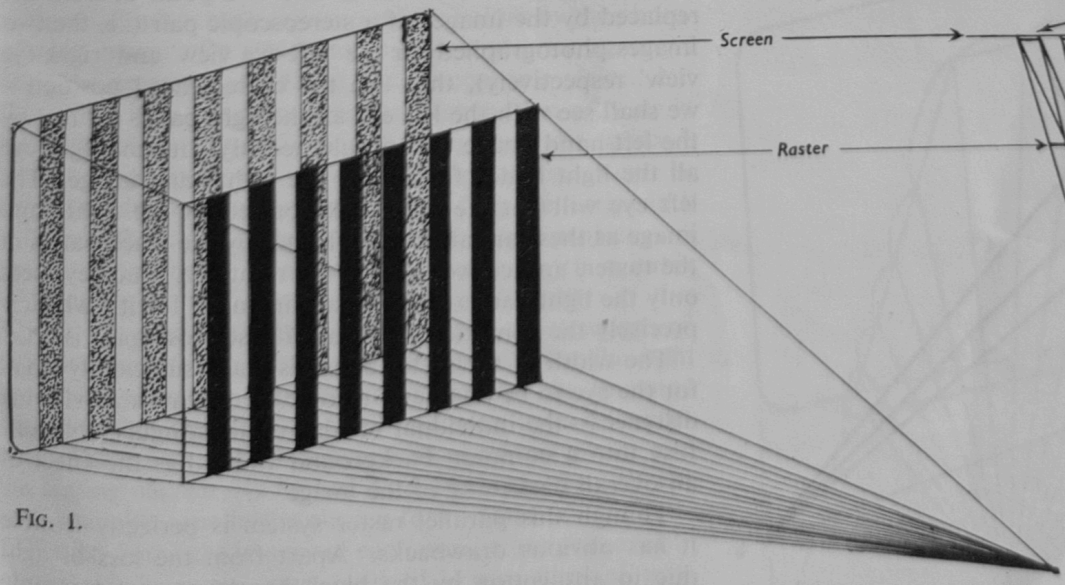


FIG. 1.

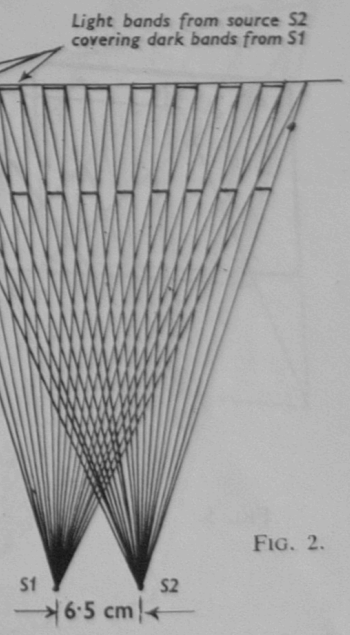


FIG. 2.

FIG. 1.—A parallel grid or raster in front of a screen illuminated by a point source of light. The width of the bands and the distance between raster and screen have been greatly exaggerated for clarity. S is the point source of light.

FIG. 2.—Two point light sources, S_1 and S_2, placed so that the light bands from one source exactly cover the dark shadows from the other source. (Distance between raster and screen again greatly exaggerated.)

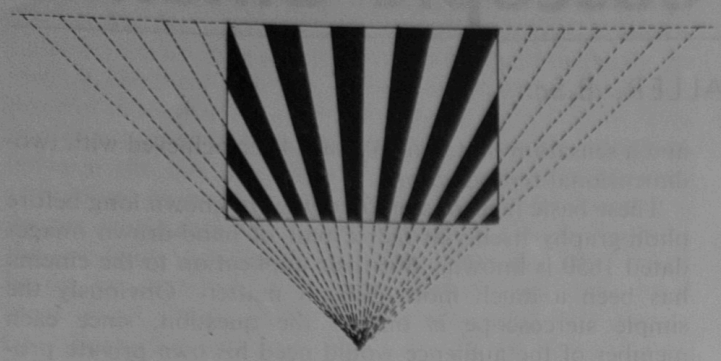


FIG. 3.—A 'radial perspective' raster. The width of the bands is shown greatly exaggerated; *there are some 2000 bands on the actual raster.*

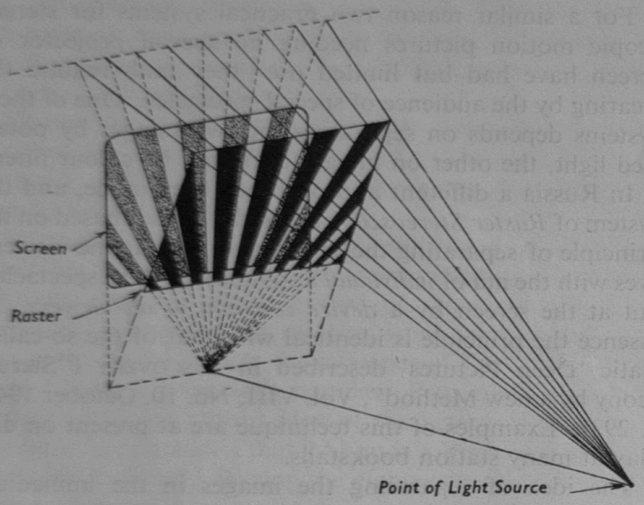


FIG. 4.—Relative positions of radial raster screen and light source.

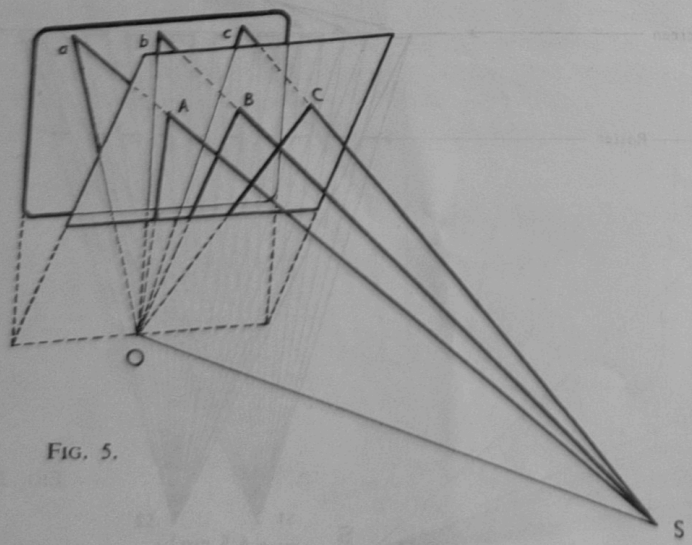


FIG. 5.

the first time by Berthier in 1896 and simultaneously by Liesegang. A little later on an American, Frederick Ives, developed from Berthier's system the so-called 'parallax stereogram' method. In 1904 he submitted several of these parallax-stereograms to the French Academy of Sciences. The Berthier-Ives principle can be regarded as the foundation of raster stereoscopy.

Consider a grid, or *raster*, made up of parallel black bands, the distance between bands being exactly equal to their width. If such a raster is placed in front of a white screen and parallel to it, and a point source of light placed in front of the raster, then the screen itself will be illuminated only where the light passes between the black bands of the raster; in other words there will be on the screen a pattern of parallel dark shadows cast by the black bands of the raster (Fig. 1). (The width of the bands and the distance between raster and screen are shown greatly exaggerated for clarity.) The shadows and the bands of light will all have the same width, no matter what are the relative distances of raster and screen from the light source, as can be seen from elementary geometry.

By shifting the head to right and left, keeping our distance from the raster the same as that of the light source, in some positions we shall be able to see all the bands of light on the screen through the slots in the raster, while in other positions we shall see no light bands at all, since they will be exactly hidden by the black bands of the raster.

Now put another point source of light at the same distance from the raster as the first, and in such a position that the bands of light formed on the screen by this second source fall exactly on the shadows from the first source (Fig. 2). Make the distance between the two light sources equal to that between the two eyes (the interocular distance is 6·5 cm. on an average). Then if the right eye is in a position from which it can see all the light bands from the right-hand source, the left eye will see all the light bands from the left-hand source.

Clearly the point source of light can be replaced by a small transparent photographic image such as a frame of film (the standard 35 mm. film frame measures approximately 21 mm. × 15 mm.) and the above argument can be applied by considering every point of the image as a separate light source. So if the two-point sources are replaced by the images of a stereoscopic pair (i.e. the two images photographed for the 'left-eye view' and 'right-eye view' respectively), then—in the correct head position—we shall see with the left eye all the light bands formed by the left-hand image and simultaneously with the right eye all the light bands formed by the right-hand image. The left eye will not see the bands formed by the right-hand image as these are all hidden from it by the black bands of the raster, and conversely for the right eye. Each eye sees only the light bands of the image intended for it—which is precisely the condition necessary for stereoscopic vision.

The width of the raster bands is made sufficiently small for the eye to be unable to resolve them at normal viewing distances—the individual bands are indistinguishable and fuse into a common background which has the effect of an overall darkening of the image.

Though this parallel raster system is perfectly feasible it has obvious drawbacks. Apart from the loss of light due to absorption by the black bands, true stereoscopic vision occurs only for one row of viewers at the same distance from the screen as the projector. True, all viewers in the same *vertical* plane would be satisfied and not demand their money back, but even assuming specially designed

cinemas on the skyscraper principle, seating capacity would be severely limited—not to mention the casualty list due to vertigo!

A practical solution to this latter geometrical difficulty is that of the Soviet inventor S. P. Ivanov. His invention substitutes the parallel raster by a 'radial perspective raster' in which the black bands converge towards a point, usually below the screen (Fig. 3). The raster is placed at an angle to the screen, the planes of raster and screen meeting along a horizontal line; this line passes through the convergence point of the raster bands (Fig. 4). In Figs. 3 and 4 the band widths are again greatly exaggerated, as is also the angle between raster and screen. The bands of light formed on the screen by a point light source will also be convergent, and each light band can be seen from anywhere in a plane passing through the corresponding slot in the raster and the light source. For example (Fig. 5) the light band Oa on the screen can be seen from anywhere in the plane OAS passing through the raster slot OA and the light source S; the light band Ob from anywhere in the plane OBS; and so on. And *all* the light bands can be seen simultaneously through their corresponding slots from the intersection of these planes, that is, from anywhere along the line OS.

But OS is not the only line having this property (that all the light bands on the screen can be seen at the same time from anywhere along it). The reader can prove for himself by constructing a space model out of thin card that there is a whole family of such lines radiating from point O; from anywhere along any of these lines the light bands on the screen can all be seen at the same time through slots in the raster—not the corresponding slots but neighbouring ones. These lines, or 'focal zones' as they are called, pass through the theatre auditorium and all lie in a plane passing through point O and the light source S.

Repeating the argument for the parallel raster, add a second point source (for the other eye) at the correct interocular distance of 6·5 cm. from the first source, and once more we get a second series of focal zones: alongside each focal zone for the left eye (cross-hatched wedges Fig. 6) there will be a focal zone for the right eye (dotted wedges). Replace each point source as before by the photographic images of a stereoscopic pair, and once again we have the necessary condition for stereoscopic vision, but this time with a far more practical distribution of seats in the auditorium. By raising or lowering the light source S relative to point O, the plane containing the seats can be given any desired angle or 'rake' including the horizontal.

In fact, the radial raster makes stereoscopic projection a practical possibility in almost any cinema with suitable adjustments in the seating. A major difficulty in this respect, however, is the large areas of 'pseudo-stereoscopy' in which the left eye sees the image intended for the right eye and vice versa, and the brain receives the uncanny sensation that the whole picture has been turned 'inside-out'. These areas occur between all the focal zones and the seating capacity is limited to something like half the total available area in the chosen focal plane.

The left and right images of each picture are presumably printed side by side on one standard 35 mm. film and projected by a normal cinema projector fitted with a simple optical beam-splitter which gives the necessary 6·5 cm. separation between the centres of the two image-beams. (The point is not made clear in the original article.)

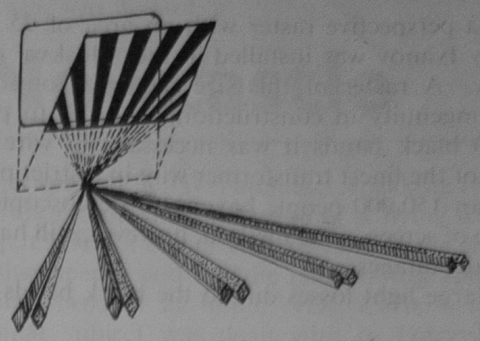


FIG. 6.—Focal zones for left and right eye with a radial raster.

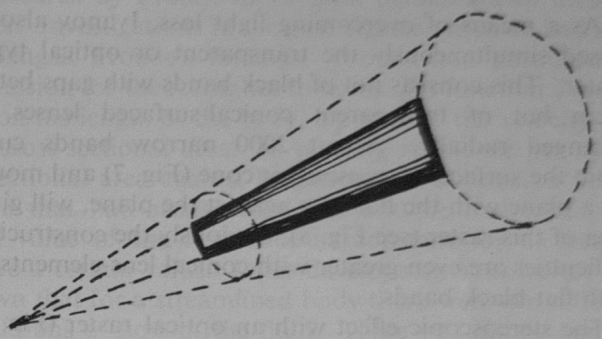


FIG. 7.—Lens element for transparent optical raster.

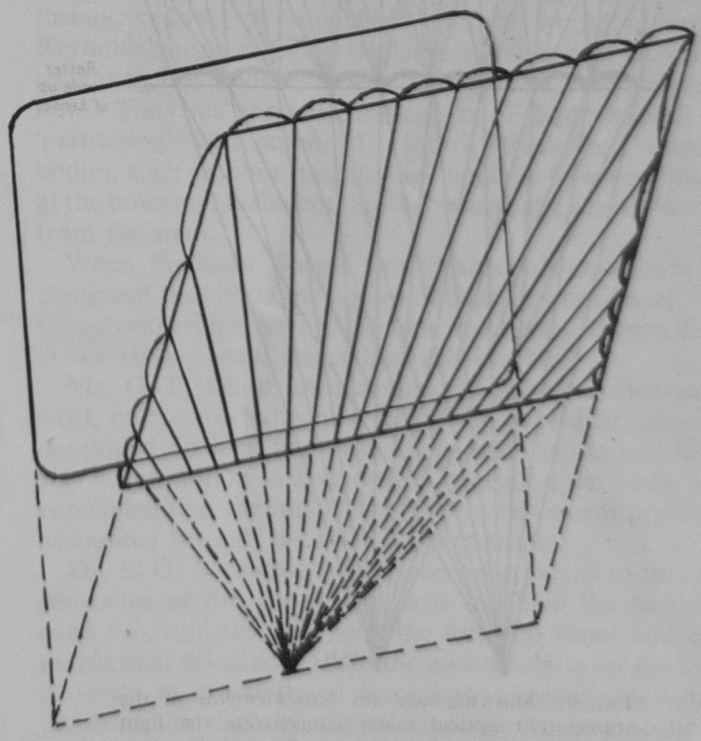


FIG. 8.—Transparent optical raster.

In 1941 a perspective raster with an area of 25 sq. m. designed by Ivanov was installed in the 'Moskva' cinema in Moscow. A raster of this size required considerable effort and ingenuity in construction; in order to provide about 2000 black bands it was necessary to wire up to 150,000 m. of the finest transformer wire in a strict pattern.

More than 150,000 people have seen stereoscopic films on this type of screen. The method, however, still has these further disadvantages:

(1) The large light losses due to the black bands of the raster.
(2) The complicated structure of the raster which precludes its wide use.
(3) The necessity for the viewer to choose a definite position (the eyes must be placed exactly in the focal zones).

The Transparent Optical Raster

As a means of overcoming light loss, Ivanov also proposed simultaneously the transparent or optical type of raster. This consists not of black bands with gaps between them but of transparent conical-surfaced lenses, also arranged radially. About 2000 narrow bands cut off from the surface of transparent cone (Fig. 7) and mounted on a plane with the flat part against the plane, will give an idea of this raster (see Fig. 8); obviously the constructional difficulties are even greater with conical lens-elements than with flat black bands.

The stereoscopic effect with an optical raster (Fig. 9) is obtained in very much the same way as with the light-absorbing raster (Fig. 2). With the latter, however, only part of the image falls on the screen, while with the optical raster the whole the of light falling on the raster is focused on the screen by the raster lens-elements in the shape of narrow bands of light. The optical raster thus gives a brighter and sharper image than the light-absorbing raster for the same intensity of light source.

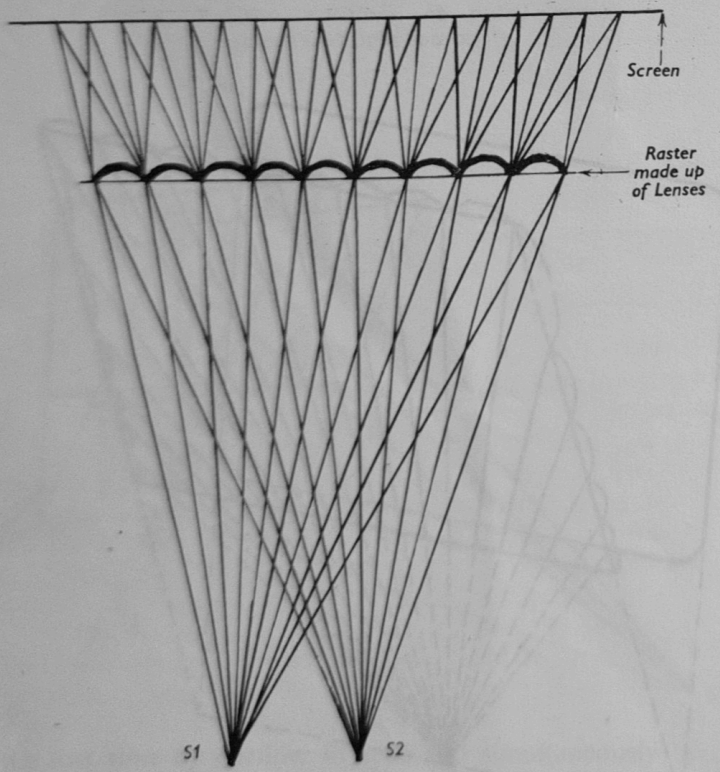


FIG. 9.—Showing how the lens elements of the transparent optical raster concentrate the light from the two point sources S_1 and S_2, into bands on the screen.

When looking at an object in real life, we can shift our head and see the object from different points of view. The projection of two images on the stereoscopic screen, on the other hand, is like looking at an object in real life from a *fixed* position. To increase the realistic effect it would be necessary to project on to the screen more than two pairs of images. The viewer, by shifting his head to right and left, would then not only experience a more natural effect but would also free himself from the last drawback of stereoscopic cinematography, that is of having to choose a definite position during the showing of the film and sticking to it. By shifting his head to right or left he would not lose stereoscopic vision but simply change from one pair of images to another. This method is employed in the static 'Deep pictures' referred to above.

No 'spectacles' system can provide for more than *one* pair of images projected on to the screen with subsequent separate vision of the pairs. Only a system not using spectacles, such as the raster system, permits the simultaneous projection of *several* image-pairs. The stereoscopic screens now made can actually be used for the simultaneous projection, with subsequent separation, of five or six image-pairs; but at present, owing to the relatively low resolving power of cinematograph film emulsion, it is impossible by using only one film of standard 35 mm. width to obtain more than two images within the frame area without the grain of the emulsion becoming visible on the screen. Obviously with emulsions of increased resolving power, it will become possible to increase the number of image-pairs and thus gradually change over to multi-pair stereoscopic cinematography.

This property of the stereoscopic screen can be called its 'capacity'. An ordinary 'flat' screen has a capacity of unity: a stereoscopic screen, depending on the number of images projected on to it, can have a capacity of two or more units.

The first Stereoscopic Cinema with an Optical Raster

At present there is a stereoscopic cinema in Moscow using Ivanov's optical screen with an area of 3 × 3 m. In spite of a number of technical defects inevitable when any new system is tried out in practice, the results have aroused great interest. This is the first stereoscopic cinema for a wide public in the world using an optical raster; the Soviet scientists and engineers who have developed the system undoubtedly hold first place in this respect. It is claimed that further improvements will enable the method to be more widely used in the near future.

In conclusion, the following extracts from an eye-witness account—that of Joseph Macleod, reproduced by kind permission of the British Film Institute Quarterly *Sight and Sound*—may be of interest:

"The cinema is a former concert-hall seating about 220 . . . A voice on a loudspeaker . . . advises you not to move your head from side to side once the show has started. As a result of this advice, everybody begins peering sideways and inclining his or her head to see what happens.

"What happens is that a kind of rising-sun effect appears to fill the screen, raying out from the centre

[Continued on p. 361

In this issue we conclude the report on the British Association meeting at Newcastle, to which nine pages of the October issue were devoted.

The B.A. at Newcastle

In his address to the Engineering Section, Sir Arthur P. M. Fleming, discussed what ought to be done to bridge the gap between science and industry. After referring to a number of engineering achievements, in both electrical and mechanical engineering, associated with Newcastle, he pointed out how many such achievements (such as Sir Charles Parsons' turbine) resulted from the patient and persistent work of inventors and industrialists based on the fundamental discoveries of the scientist, and such discoveries will always be a starting-point for new industrial enterprises. "Today, however, the function of science in relation to industry is not only to provide a new idea which may have industrial application but also to provide the means whereby that application can be most completely achieved. The achievement will always involve many industrial problems, and it is in the surmounting of these problems, whether they be associated with men, materials, machines or money, that is the modern conception of the application of science to industry."

Sir Arthur Fleming took the same line as Sir Henry Tizard did at last year's British Association, and foresaw that at the present time there would be a better return from the application of existing knowledge than from new discoveries. To maintain our lead even over less experienced competitors Britain must turn to account all our assets of skilled craftsmanship and technical and scientifically trained personnel. Particular attention should be given to the education of industrial research workers, development engineers and higher management executives. He also said that the teaching staffs of universities and technical colleges should have greater opportunities for keeping contact with industrial practices that are expanding and changing rapidly.

He pointed out that in nuclear physics great potential benefit will accrue to the United States because large numbers of scientists are gaining experience in the practical applications, and will be able to turn to industrial account new discoveries that may be made in this field of science.

"It will be the shortage of adequately experienced scientists that is most likely to delay corresponding progress in these new industrial fields in Great Britain," he said.

Locomotion in Fish

An interesting discussion followed a paper by Professor J. Gray in which he poured cold water on observations that led to claims that fish could swim at speeds above 7 m.p.h. The chief interest centred on the behaviour of flying fish. T. C. Carter of Cambridge, quoting a figure of 40 m.p.h. for their speed, said that this would be quite impossible in air if the fish's speed in water was only 7 m.p.h. To this Professor Gray replied that an impulsive kick on leaving the water would accelerate the fish, and he was sceptical of the reports of great speeds. A. G. Lowndes of the Marine Biological Station at Plymouth said he had observed flying fish from the deck of an Elder Dempster liner, itself a slow ship, and he considered that the flying fish were not travelling much faster than the ship itself. Another speaker, a naval architect, speaking from personal observation, said that the speed of a flying fish in air was 15 m.p.h. Dr. G. S. Carter, returning to the championship of higher speed, said that he had photographs showing a terminal speed of 25 m.p.h. (Dr. Carter's work on this particular subject was dealt with in Discovery, March 1946, p. 70.)

Professor L. C. Burrill, speaking as a naval architect, gave the next paper, in which he developed qualitative considerations of motion of a body through a viscous fluid, and then went on to show that quantitatively this branch of hydrodynamics had been handicapped by the influence of research by Froude in 1872 on planks drawn through water. Investigations in the past eighteen months had now challenged Froude's findings. Froude had produced an expression for the resistance in terms of a function depending on the length of the body, a power of the velocity and the cross-sectional area. In plotting resistance per sq. ft. of sectional area against length he had obtained a falling curve that had straightened out and he had taken this final value of the resistance as constant for all lengths above a certain value. Later developments, however, had shown that for a streamlined body there were two different conditions of flow of the fluid. There was purely laminar flow, with the stream passing round the body in layers that moved on each other, and there was turbulent flow which occurred quite close to the body and changed into laminar flow at a short distance from the body. Both were assuming smooth surfaces. Any roughness increased the turbulence. Two curves were thus produced if a complex expression for the resistance was plotted against the Reynolds number, one curve for laminar flow and one for turbulent flow. A roughened surface would at small Reynolds' numbers follow the laminar curve, and then, with increasing Reynolds' numbers, transfer to that for turbulent flow. Thus an anomaly noticed by Froude himself as 'perplexing' was explained. Many streamlined smooth bodies, such as ship models had laminar-flow conditions at the bows and turbulent flow beginning at a short distance from the stem.

When Professor Burrill had finished his exposition he confessed that he knew nothing about the motion of fish, though experiments with dolphins in a tank had been done at the Haslar naval research establishment.

Mr. G. E. Gadd, in a detailed paper, described some work on the mechanism of movement in slender fish. He developed an idea that with these, such as an eel, there was water motion in a vertical plane round the body, and concluded that the undulating bodily movement probably accounted for half the total forward thrust.

Dr. E. G. Richardson described experiments to find the resistance of fish forms. He had weighted the heads of dead fish, and then dropped the fish into water and estimated their velocities. He found an expression for the force in terms of gravitational force less a complicated drag involving the viscosity, the velocity and the cross-sectional area. But a fish was not a rigid body, so Dr. Richardson

tried experiments with a flag in a wind-tunnel, the undulating movement being, in his opinion, similar to that of a fish in motion. He found that as the speed of flow was increased from zero there was at first a slight fall in resistance, succeeded by a rise that continued. He did not support the theory that fish had abnormally low skin resistance.

In the final discussion, all the experimental conditions mentioned were objected to by some speaker or another. It was a confusing discussion in which Professor Gray again said that what we now needed was more intensive investigation of the hydrodynamics of motion. It was evident finally that despite the work done by zoologists and engineers we still do not really know how a fish swims.

Spawning Salmon

THE spawning habits of the Atlantic salmon, on which there has been much uncertainty, were illustrated before the section of zoology by Dr. J. W. Jones from a cinema film obtained from an observation chamber built in collaboration with C. M. King, of the Dee Fishery Board. The chamber was 33 ft. long and 5 ft. wide and high. Inside it, a natural spawning ground was reproduced.

To make her 'bed,' the female turns over on her side and, with her body arched scoops a depression 8 to 12 in. deep with her tail fin. While 'cutting', she is courted by the cock fish, and mature male salmon parr are always near her.

Oviposition and fertilisation take place with the female and cock side by side, and in less than a minute, during which the parr show great excitement.

The female then moves 1 or 2 ft. upstream, and by vigorous cutting movements covers the eggs with gravel. Usually the adult male moves away; but the parr stay on the eggs until driven off by the gravel.

Farming, Science and Education

PRESIDENT of Section M (Agriculture), Professor N. M. Comber, was too ill to attend the meeting, and his paper on "Farming, Science and Education" was read in his absence. In this he stressed the fact that agricultural science was only a youngster compared with farming itself, and in the early period of its development it occasionally suffered from its own exuberance. Its contribution to agriculture had now become indispensable. He cited the example of the Rothamsted field experiments. He went on to say, "I take a second place to nobody in my estimate of the great value of this work or of the increasing value of this type of work that has been made possible by the help of the statistician, but I would point out that in its essence it is only a continuation in a more orderly way of the acquiring of knowledge by experience which has been going on all through the ages. By arranging carefully thought-out plots and making systematic observations on the crops we can ascertain that applications of certain substances to the soil have certain effects upon the plant. By doing this, however, we are only getting the same kind of knowledge that men had been accumulating more slowly in their experience. We are not getting a different kind of knowledge, we are only getting it more quickly. We are not in this way getting a more fundamental understanding of what is going on. These experiments are an expeditious extrapolation of the more haphazard way of acquiring knowledge.

"There is of course a wealth of agricultural science apart from empirical field experiments. It is significant, however, that this work, at any rate in relation to crop husbandry, has been least intensive in the most fundamental matters and most intensive in connexion with more recent developments, and that is why we are still so dependent upon the empirical experiment. We have a considerable knowledge of genetics and plant breeding, there is much work done in the problems of plant pathology, bacteriology, mycology and entomology, the long-standing science of botany has brought detailed knowledge of the plant and the much more recent science of pedology is bringing new knowledge of the soil, of its formation, its morphology and the structure of its materials. But the basis of it all is the relationship of the soil and the plant, and that is an almost unexplored field.

"In most of our modern industries processes have been worked out from known principles. The chief processes may give rise to secondary problems requiring theoretical study, but in the main the theoretical knowledge has preceded the process. It is the other way round with farming."

In the course of his discussion of advisory work, Professor Comber described the separation of teaching and advisory work which resulted from the setting up of the National Agricultural Advisory Service as a major tragedy in the history of agricultural education. He made it clear that the progress of agricultural science should not come only from experimentation by professional scientists, and he referred with evident regret to the passing of the phase in the Royal Agricultural Society's history when nearly every paper in its journal was written by a *farmer* describing his own experiments and experiences.

Professor Comber wanted to see more teaching establishments come into being for farm workers, and he proposed that new types of educational programmes ought to be devised for the more practical minded people; 750,000 people work on the land in England and Wales, and about 15,000 of them might benefit from courses designed to develop their technical interest. Clearly the fifty farm institutes in existence could not cope with that number. There are voluntary organisations, notably the Federation of Young Farmers' Clubs, that have rendered invaluable service in the development of informal education for people entering the agricultural industry, but there is scope for a good deal more provision of some kind of day or evening classes.

Three sectional presidential addresses—Sir Godfrey Thomson's "The Nature of the Mind's 'Factors'" Prof. W. J. Pugh's address on "Lower Palaeozoic Rocks" and Sir Fred Clarke's "The Widening Scope of the Study of Education"—are omitted entirely from this report as they cannot be satisfactorily condensed or extracted: readers will be able to consult the full text of both addresses when they are published in *The Advancement of Science*.

Archaeology and Education

ARCHAEOLOGY ought to be taught in schools, was the plea of Mr. Miles C. Burkitt in his address to Section H (Archaeology and Anthropology). "I know the curriculum

is very crowded, but I do plead that some of the items should be examined as to their importance. I was educated in private schools and at Eton. Throughout my boyish days I had to do algebra and Latin verses. I have not found those subjects of the slightest use to me in after life. The mental training given by such subjects could equally have been given me by a study of geology, which would have made every railway journey I took a far greater fascination. We are living in a life of flux. Many of our institutions are being stirred up. Before these settle down again let us consider whether this new and potent subject would not be more valuable than some which have their acknowledged places today. Of course, there is the problem of teachers. But this does not worry me. The subject is so fascinating that any school teacher deciding to 'mug it up' will find himself caught up, as it were, and reading it as he would his favourite novel."

Ecology and Land Use

THE need for greater planning, first emphasised by Professor Dudley Stamp in his presidential address to the geographers, was implicit again and again, especially when, at the joint session of Agriculture and Forestry, the long-awaited battle between hill-sheep and forestry—rival claimants for the northern hills—took place. Despite the eloquence of the extreme protagonists of the two systems of hill-land use, it is probable that the answer lies, as Professor G. W. Robinson (himself a soil chemist) indicated, in a mosaic of medium or largish blocks of land under one or other system. That sheep-farming pure and simple cannot be longer tolerated over large areas under present conditions, would appear to be evident, for, as Dr. Darling pointed out, it is this very practice which has resulted in the deterioration of much hill land to a state in which forestry would seem the only use to which it can economically be put. This again raises the need (to which Dr. Darling also devoted another paper) for the rapid evolution of agricultural ecology as a science in its own right.

The emphasis on the study of ecology was again apparent when the Forestry section discussed some of the problems of afforestation of 'difficult' moorlands, for it is obvious that the gaps in our knowledge of many of the problems involved, and of their interaction, are in fact an ocean in which small islets of information form, at present, a very scattered archipelago. Forestry in these areas may well be regarded, as Dr. Darling said of farming itself, as a matter of "applied ecology". For the forester, a typical and very important problem is the need for a study of the real effects of ling, *Calluna*, the prime constituent of the ground flora over a great part of the Forestry Commission's holdings, on spruce, since the struggle between these two species is one of the key problems in afforestation in Britain. Further ecological research will be needed to discover the effect of the stand of grown timber itself on the soil, since it is already known that a dense cover of conifers may in the long run do as much harm as good by giving rise to over-acidity in the forest floor.

Two other problems with which agriculture is having to deal were made apparent more on the visits of these sections than from papers or discussion, namely, bracken and rabbits. That the former is spreading disastrously, and for reasons not yet at all understood, was evident to anyone who travels the Border country, or, in fact, any of the marginal hill land of Britain. The extent to which we are infested with rabbits is such common knowledge that we have come to take it for granted, and possibly only those who have seen the amazing development that is possible in a rabbit-free area, such as Kyloe woods, visited by the Forestry section, can appreciate to the full the benefits we should reap by the extermination of this unmitigated pest.

Artificial Mutations

THE botanists and zoologists held a joint session and talked about the artificial production of mutations.

T. C. Carter of Cambridge, spoke on "The induction of mutations in small mammals by radiations."

Mr. Carter told how these studies were intensified in the U.S.A. during the war and extended to include gamma rays from radioactive materials, and neutrons from atomic piles. The main object of the war-time work was to provide a basis for rules to safeguard the health of workers on atomic projects.

The final paper, by Dr. Charlotte Auerbach, was on the production of mutations by chemical means, in particular mustard gas. Among more recently discovered mutagens are *urethane*, which is also used in cancer therapy, and *formalin*, which acts when mixed with the food of *Drosophila* larvae. Among substances with weak mutagenic action are a number of carcinogens, but the correlation between carcinogenic and mutagenic effects of chemical substances cannot yet be considered as conclusively established.

THE RUSSIAN STEREOSCOPIC CINEMA —continued from page 358

bottom and disappearing as soon as you restore your head to its normal position. . . . Otherwise, there is only a slight discomfort as if there were something in front of your eyes, gauze perhaps . . . I doubt if my eyes would have been very happy after much more than the hour and a quarter of stereoscopic film in its present state of development.

"The story was *Robinson Crusoe* . . . when Crusoe in his shipwreck throws a rope to a drowning sailor you get the first shock. The rope comes hurtling and curling right out of the screen into the darkness over your head. At you! You duck. We all did. After that we were ready for anything. . . .

"Sometimes the foreground itself comes alive. As Crusoe advances down a corridor of undergrowth, the camera tracks backwards in front of him. Out in the auditorium, about three rows in front of you, leaves and lianas materialise in the air, dangle and dance, and float away into Crusoe's face. Parakeets and small birds sit on them; or fly at you from the screen and vanish over your head; or form themselves out of nothing into a cluster of wings in the darkness. . . .

"The close-up of a hand making fire with a burning-glass raises interesting speculations about the special advantages of three-dimensional documentaries in time to come."

The Atom Devalued?

E. M. FRIEDWALD

THE official announcement that an atomic explosion took place in Russia some weeks ago came as something of a shock to the people of the West. Yet ever since Hiroshima they had been repeatedly told that the secret of the atomic bomb could not be kept indefinitely in American hands, that within five years other countries would have succeeded in mastering atomic technique. For the real secret was revealed at Hiroshima—when the Americans proved that an atomic bomb could be realised in actual practice. Once this secret was out, it was only a matter of time before other nations made use of it. The only surprise, and a mild one at that, is that the Russians have succeeded one year earlier than experts had predicted—though several years earlier than public opinion was willing to believe. But now public opinion is tempted to go to the other extreme; it is inclined to feel that, by producing the bomb, Russia has drawn level, or is about to draw level, with the United States in the atomic field.

How far is such a view justified? To what extent, if any, has the American atom bomb been devalued by this sudden rise in Russian atomic stock?

To answer this question, one must separate the scientific and technological aspect of this new development from its political and strategic implications. For if the manufacture of the initial bomb solves nine-tenths of a country's scientific and technical problem, it does not go very far towards solving its political and strategic problem. What really counts in this respect is not the ability to manufacture one or several atom bombs, but the capacity to produce a *strategically effective* number of bombs and to deliver them to the targets with the maximum effect.

What constitutes a 'strategically effective' number of bombs depends, of course, on many complex factors. It is obvious, for example, that the number of bombs necessary to deal effectively with a country like Belgium would be of little strategic effect if used against a country like the United States. No less importance attaches to the means of interception, for it is clear that a device capable of intercepting two-thirds of the missiles would have the effect of trebling the number of bombs necessary to be strategically effective, whereas one capable of intercepting only 10% of the missiles would not make much difference. These considerations alone show how futile it would be to surmise in advance what constitutes a strategically effective number of bombs. All that can be said with any degree of assurance is that, with the political division of the world as it is and is likely to remain for some time to come, this number would run at least into hundreds and possibly into thousands.

Now at the time of Hiroshima, the United States had no more than two bombs, and two years later it was producing the bombs at a monthly rate which could be computed on one's fingers. In other words, the accumulation of a strategically effective number of bombs must take at least several years in the present state of technology—and that is assuming the availability of the same vast resources of raw material the United States has had at its disposal.

But such an assumption in Russia's case would, to say the least, be problematical. Geologists have recently revised their views about the extent of uranium and thorium resources; they now believe, not only that these are much smaller than was assumed a few years ago, but that the geographical location of these two minerals is much more favourable to the United States than to Russia. It may be recalled in this connexion that the three most important deposits of uranium known before the war were in Canada, the Belgian Congo and the United States, and that the fourth major deposit, situated in Czechoslovakia, is far less rich than either of the other three; while the two major deposits of thorium were in Brazil and India. Of course, the possibility cannot be ruled out that Russia may have discovered, or will yet discover, major deposits of uranium or thorium on her own or her satellites' territory, but even so it is hardly likely that the extent of these hypothetical discoveries would enable her to command resources comparable to those of the United States, at any rate not in the near future.

There is, of course, the argument that these two minerals could be obtained from the earth's crust, which contains on the average 0·0004% of uranium and 0·0012% of thorium. But apart from the tremendous cost in manpower involved in such a massive operation, there is the question of the special technological processes which would have to be worked out. For it is obviously one thing to treat a mineral containing 1% or 2% of uranium, and quite another to treat a material containing 2500 to 5000 times less uranium. To evolve special technical processes for treating such dilute material cannot but be a lengthy and difficult procedure; and even when the technical difficulties are mastered, it will take much more time to extract the same quantity of pure uranium from the earth's crust than from a rich ore. In a word, it is all a question of time.

But this time factor is of vital importance in the political and strategic sphere. Let us assume, for argument's sake that 500 is the strategically effective number of bombs. Then a country which commanded sufficient resources of raw material to produce six bombs a month would build up a strategically effective stock of bombs in seven years; whereas a country which, for lack of raw materials, could produce only two a month would need over twenty years to build up such a stock. But all available evidence points to the fact that, for some years to come, something like this ratio may obtain between the United States and Russia. The former, thanks to its vast resources of raw material, is already in possession of a very significant number of bombs and may not be far from reaching a strategically effective number; the latter, because of her limited resources of raw material, may have to work for years before accumulating any significant number, and much longer before reaching a strategically effective number. Thus the gap between the United States and Russia, far from diminishing as has been assumed in the heat of the moment, is bound to go on widening until such time as Russia has accumulated a significant number of bombs. For once the United States has reached the strategically effective number, any further accumulation of stock would have little effect on the balance of power; and once the Russians have built up a

stock sufficient to saturate the United States, any American superiority in numbers alone would be of little significance.

But the number—and also the quality—of the bombs is only half of the problem; the means of delivering them to the target, and the ability to intercept enemy bombs count for just as much, and a marked superiority in these fields can be as important as superiority in the number of bombs. It may be pointed out in this respect that the United States is better placed than Russia as far as operational bases are concerned. But in our age the protection afforded by distance is a wasting asset. If distances are to be discounted however, all the more importance attaches to the range and accuracy of the vehicles of delivery, be they aeroplanes or long-range rockets, and to the efficacy of the means of interception. In other words, atomic supremacy is a question of capacity, not merely in the atomic field, but in the whole field of science and technology.

This inevitably raises the whole question of how soon Russia can hope to overtake the enormous technological lead of the United States. No doubt the Soviet press and radio, which have recently been at pains to convince the world that most of the great scientific discoveries and inventions were first made in Russia, will make the most of this new Russian achievement. But the manufacture of an atom bomb, spectacular as it may appear to the public at large, does not turn a technologically backward country into an advanced one. There is every likelihood that the United States will be able to maintain its general technological lead—and, therefore, its lead in the atomic field—for several years to come, provided, of course, that it makes the necessary effort. For, certainly, the Russians will spare no pains to catch up with the Americans.

U.S. Superiority Remains

On the morrow of Hiroshima the United States enjoyed an atomic monopoly, but a monopoly expressed in a small number of bombs, too small a number to be militarily decisive in themselves, once the psychological shock had been absorbed. The strategy of this period, seen in retrospect, did not differ in essentials from that of the pre-atomic era, even though this was not fully realised at the time. But as the United States turned out a growing number of bombs, we were moving towards another phase, that of American monopoly expressed in a strategically effective number of bombs, when strategy could be based exclusively or primarily on the atom bomb. Whether the Americans had actually reached that stage or were approaching it has now lost much of its importance, for the atomic explosion in Russia marks the beginning of a new phase. We now enter a period where the American monopoly is nominally at an end, but where the United States enjoys such a superiority in the number of bombs and the means of delivering them to the targets that it can still be said to enjoy a virtual monopoly. Indeed, for some years to come, the United States will be able to increase its relative superiority over Russia until the latter has built up a significant stock of atomic weapons. How long this building up will take will depend mainly on the extent of the resources of raw material available to the Soviet Union. But while this phase lasts, strategy can still be based exclusively or primarily on the atom bomb.

Eventually, however, Russia will reach the point of having a significant amount of bombs and improved means of delivery and interception. Then the present phase will gradually give place to the fourth and final stage, that of something like parity between the two major powers. For at that point the possession of more and better bombs will have little significance. If 500 bombs are sufficient to achieve the object of a policy, there is no point in using 1000; and a global range is as good as a twice-global range.

But we are still far from that stage and all the available indications are that it will not be reached for quite a number of years yet. Indeed, it may never be reached—if the principal Powers meanwhile agree to set up an effective system of international control of atomic energy. In what way does the possession by Russia of the atom bomb affect the chances of such an agreement?

International Inspection Essential

Until now one of the main obstacles to the setting up of a control scheme has been Russia's unwillingness to submit to any system of international inspection that would be effective and fool-proof. Now two or three years ago, when there was no reason to assume that Russia possessed any atom bombs, the initial inspection necessary to put the control scheme into operation would have been comparatively mild. How much more severe inspection would have to be now that Russia is known to be producing atom bombs and may have some stocks of fissile material. The logically minded may think that if Russia refused to submit to a relatively mild inspection, she has all the more reason to refuse to submit to a more severe inspection. On the face of it, Russia's success in producing the atom bomb seems to me to have lessened rather than increased the chances of an atomic agreement. For inspection, a full, unfettered and thorough inspection, is the *conditio sine qua non* of any effective control scheme. It cannot be repeated too often that, if there be anything worse than no control scheme at all, it is a control scheme that is not fool-proof. For a system that leaves loopholes for evasion can only give a false sense of security to the unwary, and put temptation in the way of the would-be aggressor.

Contrary to the popular view, the atomic explosion in Russia has not brought with it any appreciable alteration in the balance of world power, and is not likely to produce any radical change for some time yet. But in one respect the event may prove momentous; for in breaking the American monopoly, it has destroyed the last vestige of that deadly complacency which has been the worst enemy of clear thought, and put dramatically before the world the issue which has confronted it ever since Hiroshima. No sacrifices should be spared to set up an atomic control scheme embracing the whole world—short of those which could be made at the expense of the soundness and efficacy of the control system. But should a global alliance prove unattainable, the rest of the world will soon have to make up its mind whether an atomic alliance without Russia is not a better solution than leaving each nation to play with its own atom. The distant explosion in Russia a few weeks ago may yet shake the world.

The Bookshelf

London's Birds. By R. S. R. Fitter. (London, Collins, 1949, 256 pp., 10*s.* 6*d.*)

HERE is a bird book that is different. Few authors have claimed to treat London's birds exclusively; but in restricting his coverage to the county boundary, arbitrary as he reminds us it is, Mr. Fitter has produced a book that is of outstanding interest to the town ornithologist.

There is something about London that seems to engender bird-watchers and, whether they be expert ornithologists or leisure-time amateurs, they will find this book full of interest, stimulating and a valuable work of reference.

Here is none of the pessimism that so often disheartens the bird-lover when he deplores the passing of the countryside as the great town sprawls over it. The enormous growth of London with all the changes it brings is as much an ecological factor as the planting of a wood or the ploughing-up of a hillside far away in the country: and in the growth of the great town we see the impact of man on nature on the grand scale. Nor are the changes all losses, for who among the older naturalists would have dared to suggest that the shy Wood-pigeon would nest in city streets and become so tame as to feed from the hands of passers-by in the parks; or that the Black Redstart, of all rarities, would become a regular breeding bird in the heart of the City?

The author has had in mind the living bird striving to fit into a rapidly changing world, persecuted often by man, sometimes befriended by him; failing all too often, sometimes succeeding and occasionally flourishing exceedingly in the strange environment.

The history of the changes in London's bird population is a fascinating story and not the least interesting factor is the changing attitude of man himself to the birds that seek to survive in a habitat that is largely bricks and mortar.

For such an area as the County of London presents as interesting, varied and exciting ecological problems as the New Forest or a Yorkshire moor, and the author of *London's Birds* certainly makes the reader feel this to the full when he suggests problems worthy of the expert's attention and often not beyond the capabilities of the enthusiastic beginner. Nor will it be London bird-watchers only who will read this book with profit. Town-dweller and countryman alike will find much to interest them and to stimulate further observation of the birds around their homes.

The book is well indexed and appropriately illustrated. W. H. S.

The Universe and Dr. Einstein. By Lincoln Barnett, with a foreword by Albert Einstein. (London, Victor Gollancz, 1949, 112 pp., 5*s.*)

THIS little book is a restatement of Einstein's work and its importance in the development of physics, together with a small amount on quantum theory, wave mechanics and modern cosmologies. There are fifteen short chapters, which first appeared serially in *Harper's* in America. The exposition is of such a quality that Einstein was persuaded to write a foreword. He has achieved this in 270 words, a model for all time; for with these few words he packs in a statement of the problem facing all popularisers of serious science, an appreciation of the need for this procedure—"Restricting the body of knowledge to a small group deadens the philosophical spirit of a people and leads to spiritual poverty"—and a hint of theoretical insufficiency today.

Where does this book stand in relation to other expositions on the same subject only, of which there have been many in the past thirty years? Let us eliminate all the large and specialised books. Let us eliminate all the pseudish that dragged in religion and philosophy and in which the authors produced wide-eyed rhapsodies about a space-time continuum that was finite and unbounded and about measuring rods that changed their lengths like conjurors' wands. We cannot even fairly include Philipp Frank's excellent exposition because it is not a small work and is part of a biography.

These things being done, we are left with three of note—by Einstein, Bertrand Russell, and Lincoln Barnett. The foremost, in my view, is Einstein's own, translated by R. W. Lawson and first published in this country in 1920. It was a somewhat bald narrative though enlivened by good analogies, of which Mr. Barnett now makes good use. In it the steps from the first doubts were given one at a time, and the author explicitly warned his readers twice that they would need patience and 'force of will'.

Second in importance comes this present book, which is of course up to date. It is the tiniest bit obscure about measuring rods and clocks because of the lack of sufficient emphasis on the fact that it is according to an observer in a different reference system that the moving rod contracts and the clock beats more slowly. It is a little careless in the index—no entry for 'clock' or 'measuring rod'. But these are small faults. Attractively written, it can be read gainfully by all intelligent adults, and every young pupil claiming intelligence should be presented with a copy. For anyone in need of exposition in the best deskside manner this is indeed the book. C. L. BOLTZ

Russian Science Reading. By L. Light, Ph.D., A.R.I.C. (London, Hirshfeld Bros., 1949, 98 pp., 7*s.* 6*d.*)

THE book is intended to serve as an introduction to reading Russian scientific papers in the original. It consists of a number of extracts from Russian textbooks on chemistry, physics and biology, accompanied by explanatory notes. A complete vocabulary of the Russian words used is also included. The book should be very useful for anyone possessing a slight knowledge of Russian and wishing to start serious science reading.

It is a pity, however, that the extracts selected are so elementary. It would have been possible to have found papers easy from the grammatical point of view and yet written in proper scientific language. What is the advantage of presenting a reader with a description of electrolysis in which it is stated that electrons are 'pushed out' by the cathode and 'drawn in' by the anode? Incidentally, the latter verb is translated incorrectly in the notes and vocabulary as 'attracted'.

The proof-reading was not done carefully and there are many errors in the Russian text. The accent in the Russian word 'dyeing' shown throughout the text is not the one more generally used and words printed partly on one line and partly on the next sometimes are not divided in accordance with the Russian rules. Finally, in the vocabulary a peculiar sign only slightly resembling the small Russian letter 'zh' is used to represent that letter.

V. L. RASTORGOUEFF

Anaesthesia and the Patient. By Gordon Ostlere. (London, Sigma Books, 1949, 166 pp., 7*s.* 6*d.*)

THE science of anaesthesia has advanced a long way since the days when a man was knocked unconscious or made drunk with rum while his leg was amputated with a red-hot saw. Modern anaesthetics involve the precise administration, by an expert, of a variety of volatile substances in scientifically controlled proportions. Anaesthesia is practically 100% safe today and this, the story of artificial sleep, is told in an exciting and stimulating way by the author of this new book.

He takes us first through an interesting historical tour and then describes the variety of anaesthetics which are available today, ranging from those for intravenous use to spinal anaesthetics and to those which act by inhalation.

It is a fascinating story and the man in the street would certainly profit by reading it. The book is well turned out by the publishers and carries a useful index which, however, could have been a little larger.

Metal Rectifiers. By H. K. Heinisch (156 pp. 15*s.*). **Luminescent Materials.** By G. F. J. Garlick (254 pp. 21*s.*) Monographs on The Physics and Chemistry of Materials. (London, Oxford University Press, 1949.)

THE new series of Monographs on the Physics and Chemistry of Materials was launched on a flying start with Professor Tolansky's volume on his pioneering work on multiple beam interference, and the two books under review admirably sustain the initial level. They will certainly find permanent places on the laboratory bookshelf.

Dr. Heinisch's subject is of great practical importance in the electrical industry, and his book provides an excellent introduction for the practical engineer to the modern theoretical developments which have arisen from the

application of quantum mechanics to the theory of solids. These theories have advanced rapidly in recent years, embracing a wide range of electrical and optical properties of solids, and the time is certainly ripe for the publication of books of this kind in which the essentials of the theory, shorn of superfluous mathematics, are presented in a readable form.

Dr. Garlick's book also deals with the application of a particular branch of the same theory, but while luminescent materials are of increasing practical importance their behaviour is so complex that theory and application seldom meet. His subject is, therefore, of rather more academic interest than Dr. Heinisch's, and his book consequently is addressed to a more academic reader. The experimental study of the behaviour of luminescent materials is in fact one of the main growing points of the basic theory, and Dr. Garlick brings the reader right up to date with current experimental work—to which he has himself made a major contribution. He is mainly concerned with inorganic crystalline solids, but he includes a chapter on the luminescence of organic molecules. The point at which the theory is least adequate in explaining the experimental results is in connexion with the effects of infra-red radiation on phosphorescence, and this aspect is dealt with extensively.

Both these books can be strongly recommended to the specialist, and will provide very interesting reading for the general physicist. C. G. A. H.

Birds of Britain. By J. D. Macdonald. (London, G. Bell & Sons, 1949, 153 pp., 9 colour plates, 8*s.* 6*d.*)

THE increasing interest in all branches of Natural History brings with it a stream of books intended for the beginner in entomology, botany or, as in the present case, bird-watching. The author, in charge of birds at the Natural History Museum in London, has drawn on his many years experience in identifying birds seen and described by other people, and it is from this point of view that he presents his material. Often, it is true, the salient points that strike one who sees a 'new' bird for the first time cannot be accurately pin-pointed, and the detailed descriptions of the average bird book are of little use to the beginner. It is on these salient points, often vague enough, of 200 of our common and less common birds, that the author has concentrated.

The idea is a good one, and so is that of dividing the birds into groups according to habits and habitats. The difficulty arises in applying these ideas. The author's descriptions of many species are so short as to be of little use to anyone; a serious omission, I think, is that of reference to the songs of all but a few species, surely one of the finest means of identification; reference to nests and eggs, also, seems to be conspicuously lacking. The illustrations, consisting of colour plates of the commoner species, and drawings of many others, are fair. In the field, the book is handy and well laid out for on-the-spot identification.

P. B. C.

Far and Near

A Chemist Looks into the Future

A HIGHLY futuristic world, but one that was within the realms of possibility, was conjured up by Professor Eugene Rochow, addressing a meeting of the American Chemistry Society at which he received the Baekeland award for his important work on silicones.

The world he pictured could support a population of 15,000 million people, and would be made possible by the use of inexhaustible instead of exhaustible raw materials. Houses would be built of excavated earth fused into bricks and slabs on the spot. Meat and eggs would disappear from the human diet, because of the inefficiency of farm animals as food producers, and man would live on such foods as butter made from coal, sugar from trees, and proteins from yeast.

He foresaw rapid depletion of many natural resources if they continued to be used in the same ways as they are today. The United States, he said, has used 58% of its original petroleum reserves, and he drew attention to current efforts to supplement petroleum supplies by synthesis from natural gas and coal. But he said the time might come when coal would be denied to all industries because it would be needed for conversion into food.

Man's present eating habits will have to be radically altered before many generations pass, Professor Rochow asserted. It took nearly five acres of arable land per person to feed the United States in 1947, and on this basis, even if every bit of land in the country except deserts, swamps and rocky areas were cultivated, only some 306 million people could be supported. Moreover, forest lands could not be expected to yield as much as our present farms, and soil erosion would be greatly increased by cutting down all trees. It would be better to continue growing trees and to use them for food. Although man cannot digest cellulose from trees directly, the cellulose could be converted into digestible sugars that would supply all carbohydrate needs.

Meat and eggs as sources of proteins seem certain to vanish from the human diet, "for a beef steer converts only about 12% of its food to meat, and does worse at it when poorly fed," said Professor Rochow. Plant proteins and fish can be used for a time, but ultimately artificial proteins probably will have to be provided through synthesis of their building blocks, the amino acids. It may prove desirable, he suggested, "to let yeast or other micro-organisms make satisfactory amino acids for us from simple fixed nitrogen"—that is, from nitrogen taken from the air. Edible fats can be made from coal, as demonstrated by the Germans.

Ultimately, Professor Rochow explained, the real problem will be to assure a continuing supply of atmospheric carbon dioxide from which plants can build their tissue. Carbon dioxide is steadily being soaked up by the oceans, and it will have to be recovered from them. If this problem, and the others connected with nutrition, are solved along the lines indicated, he said, "a United States population of about one billion people and a world population of fifteen billions would not seem unreasonable."

A New Selective Weedkiller

A RECENT addition to the range of selective weedkillers is 2,4,5-T (2,4,5-trichlorophenoxyacetic acid). This, sometimes in association with 2,4-D, has given most promising results when applied to brambles and similar weeds, stated S.W. Cheveley of Plant Protection Ltd., in a paper to the British Association.

Twenty-five Years of Aslib

TWENTY-FIVE years ago a group of metallurgical information officers met at Hoddesdon to discuss their common problems. From that group has grown Aslib, as the Association of Special Libraries and Information Bureaux is always called. 'Aslib' is now the registered name for the old Aslib and the British Society of International Bibliography, which officially amalgamated with it this year. There are now over 1000 members spread throughout the world, and nearly every important library in the British Commonwealth, industrial and Governmental, is a member.

The 24th annual conference (the war cancelled one) was held from 9th to 12th September at Ashorne Hill, near Leamington Spa, and was the occasion of some provocative remarks from Dr. Percy Dunsheath, the new President. He called for strong action to correct "the inadequacy of present-day reference library facilities in science and technology and the need for the establishment of higher standards of training, and qualifications for staff employed in scientific and technological libraries. I feel I am not going a bit too far when I say that the reference library facilities in this country in these important subjects are a disgrace to Great Britain." He deplored the present library system which was understaffed with underpaid and under-equipped librarians. He drew attention to the fact that any enthusiast who wishes to follow his subject in the evenings is deterred because

the Patent Office Library closes at 6 p.m., whereas prewar it closed at 10 p.m.

"There is a risk," he said, "of being misunderstood when one turns to America and shows how differently they do these things. The usual retort is of course, 'Yes, but wasn't it Britain that did this, or started that. We're not so backward after all?' I would issue a warning: there is considerable inertia in these matters and our past achievements, whether in war or peace, do not prove that we shall do as well in any future crisis." And he went on to say that Aslib must tell government, industry and the man in the street that the rapidly expanding store of knowledge demands new, not old-fashioned tools. He said American libraries are open from 9 a.m. to 10 p.m. on week-days, and 1 p.m. to 10 p.m. on Sundays. "There is no five-day week and no overtime outlook in learning."

He suggested that the best investment for British prosperity that the Government could make would be to create "a new Library of Science and Technology in the centre of London conceived on the grand scale, using the practical experience and tradition of the Patent Office Library and at least five times as large."

In view of the vast amount of work now encompassed by Aslib, subscriptions to new members are being raised, and a considerable proportion of present members have voluntarily increased theirs. The D.S.I.R. contributes to Aslib's support, giving a grant of £1 for every pound raised by the Association. Aslib's income is now of the order of £10,000 a year.

Correction

On p. 277 of the September issue, in the article on "Utilising the Seaweed Harvest", there was an error in the diagram giving the formulae of alginic acid and cellulose, the caption "alginic acid" and "cellulose" being inadvertently transposed.

'Artificial Rain': British Experiments

Numerous attempts have been made in America to produce artificial rain by bombing suitable clouds with 'dry ice' (solid carbon dioxide), and many successes have been obtained. Experiments with this technique were made during this summer in England. A moderate shower of rain resulted when, on August 3, an R.A.F. plane unloaded 200 lb. of dry ice on a cloud. A second attempt was made on August 8 with 300 lb. of dry ice; this was the result as recorded in *The Times* (August 15): "A cumulus cloud east of the Pennines, at a height of about 10,000 ft., was chosen for the experiment, it being calculated that the rain from it would fall in the catchment area. Dry ice was dropped at 5.3 p.m. and at 5.11 p.m. the cloud top was observed to have grown by about 500 ft. Twelve minutes later a rainbow was seen and below the cloud those in the aircraft found that a heavy shower was falling."

Night Sky in November

The Moon.—Full moon occurs on Nov. 5d 21h 09m, U.T. and new moon on Nov. 20d 07h 29m. The following conjunctions with the moon take place:

November				
15d 01h	Mars in conjunction with the moon	Mars	1°	S.
15d 14h	Saturn	Saturn	0·8°	S.
23d 19h	Venus	Venus	2°	N.
24d 13h	Jupiter	Jupiter	5°	N.

In addition to these conjunctions with the moon, Mars is in conjunction with Saturn on Nov. 30d 21h, Mars being 0·2° N.

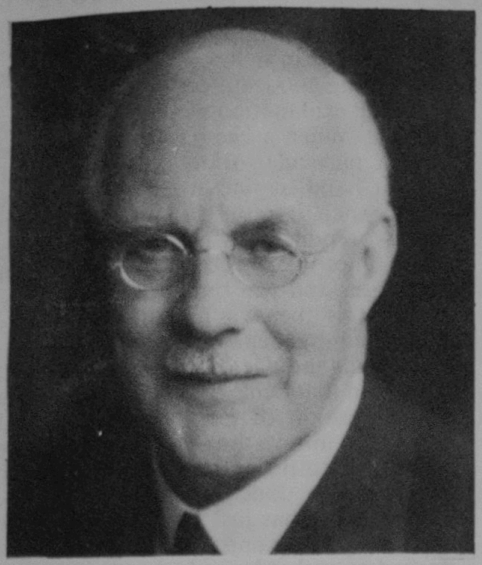
The Planets.—Mercury rises 1¼h before the sun on Nov. 1 and can be seen in the eastern sky but the planet draws closer to the sun during the month and is in superior conjunction on Nov. 21. Venus is conspicuous in the western sky, setting about 2h after the sun throughout the month. About half the illuminated disk is visible and the 'half moon' appearance of the planet can be seen with a small telescope. The apparent diameter of the moon at this time is about 75 times that of Venus and readers can imagine what the moon would look like to the naked eye if its diameter were about one-seventieth of its actual value. It will be obvious that the phases of our satellite in such circumstances would be difficult to detect. Mars rises soon after midnight but presents no interesting features for observers with small telescopes. The times of setting of Jupiter are 21h 10m, 20h 25m, and 19h 40m, at the beginning, middle and end of the month, respectively. The planet can be easily recognised as it looks very bright, is not close to any bright star, and does not rise very high above the horizon. Only those who are about in the early morning hours will see Saturn which rises at 2h, 1h 10m and 0h 15m, on Nov. 1, 15 and 30, respectively, and can be easily identified in the constellation of Leo.

The fine constellation of Orion is now coming into view and cannot be mistaken. Three stars forming the Giant's belt point downwards to Sirius—the brightest star in the heavens. Underneath the lowest star in the belt is another star fainter than those in the belt and lower still—about the width of the belt—is another star known as Iota. If you turn a pair of good binoculars on this last star you should be able to see the Great Nebula in Orion just above it. This Nebula is a wonderful sight when viewed through a large telescope and in a later issue something will be said about it. Meanwhile readers are advised to look at it with any optical aid that they have got.

Radiolympia 1949

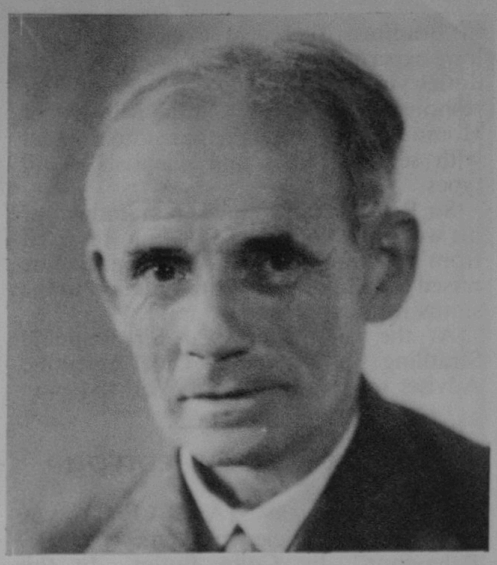
Visitors to the 1949 Radio Exhibition held at Olympia from September 28 to October 8 were given cause to remember the 1939 Exhibition which was curtailed so disastrously. Then, as now, the keynote was the coming of television, and the passage of ten years is marked by few major improvements although more manufacturers have entered the field. Apart from purchase tax, prices are not excessive and firms such as Pye Radio, E.M.I. Ltd. and Scophony-Baird have encouraged the moderate buyer by offering receivers in

TV Developments at Radiolympia. (Left): *Relay television was demonstrated by E.M.I. The photo shows receiving and relay equipment for a TV relay station.* (Below): *The Pye Colour Television Camera attracted much attention, particularly in medical circles interested in using it for demonstrations of surgical operations.*



Sir Harold Hartley, F.R.S., new president of the British Association which holds its next annual meeting at Birmingham.

Sir Reginald Stradling, F.R.S., who has succeeded the late Prof. C. H. Lander as Dean of the Military College of Science.



Mr. H. M. Garner has been appointed Chief Scientist to the Ministry of Supply, in succession to Sir Ben Lockspeiser.

the £40 class, which was the figure for a good console model before the war. There is a tendency to return to the de luxe receiver incorporating sound radio, gramophone and television and at the other extreme there are a number of designs for television receivers made from surplus service equipment and components.

Rivalling the television receiver is the combined radio-gramophone, of which almost as many were shown as ordinary mains receivers. Again, prices were high and it is a curious attitude on the part of the buyer to object to the cost of a television receiver while accepting the high cost of a radiogram. There is still a tendency to wait for a hypothetical improvement in technique or a reduction in cost of television in spite of reiterated official statements on the subject.

In the National Hall adjoining the Grand Hall a number of the leading manufacturers were showing electronic equipment and a series of exhibits arranged by the various Government departments provided a more educational contrast to the eye-catching displays on the main stands. The new 'Seascan' radar equipment of Metropolitan-Vickers was on show, with a range from 50 yards to 27 miles. Among the research exhibits were the direction-finding equipment for thunderstorm location and the ionospheric sounding equipment used by the Radio Research Station at Slough, a pulse code modulator for coding and decoding speech (Ministry of Supply) and ground controlled approach (GCA) equipment for civil aircraft (Ministry of Civil Aviation).

Nucleonic research equipment was represented by Geiger counters (EKCO Ltd.) and complete racks of control and measuring gear made by Dynatron Radio.

Two notable advances in technique are the introduction of flat-faced cathode ray tubes and tubes with aluminised screens which give increased brightness by virtue of the improved reflexion from the aluminium layer behind the fluorescent screen. The curve shows that for operating voltages less than 6 kV. there is slight improvement, but at higher voltages the aluminised screen is superior. The trend towards 'miniaturisation' of components seems to have stabilised and complete ranges of miniature and subminiature valves are now available. As one research engineer stated: "the only feature of modern equipment which cannot be miniaturised is heat", and it is this factor which sets a limit to the compression of modern electronic equipment into a small space. The introduction of numerous small components may create a new standard in rack equipment, and the somewhat clumsy 19-in. steel panel may be replaced by panels only 10 in. across or less.

Philips showed a projection television receiver. In this the intensely bright image on a $2\frac{1}{2}$-in. tube is an enlarged optical system based on the Schmidt principle (*see* DISCOVERY, October 1947, p. 305, "Two Major Television Advances") to give a final picture of 16 in. × $12\frac{3}{4}$ in.

It is to be hoped that the radio industry's policy of providing a number of more scientific exhibits will be maintained and that the Radio Exhibition will in future be representative of the best British electronic and telecommunications practice.

First International Congress of Biochemistry

THE first International Congress of Biochemistry was held this year during July in Cambridge, and attended by over 1700 delegates, including about 700 from 42 countries overseas, although unfortunately none from Germany or Russia. The initiative for calling the Congress was taken by the British Biochemical Society, and Cambridge was a happy choice in view of the long association of the University with the late Professor Sir Gowland Hopkins.

A large number of papers were presented, and the Congress divided into twelve or more sections which met simultaneously. While no outstanding developments were announced, interesting and steady progress was reported on the many frontiers of the subject.

A lecture worthy of special mention was that given by Prof. M. Florkin of Liège, who dealt with biochemical evolution. Progressive changes in biochemical mechanisms can be traced as the evolutionary tree of the biologist is ascended and systematic biochemical characteristics exist, so it should be possible to superimpose a biochemical classification upon the biological one.

There was a very large audience at the session dealing with Vitamin B_{12}, the remarkable cobalt-containing anti-anaemia factor. It was reported that a fragment has been split off the molecule and identified as *dimethyl benzimidazole*, but as this represents only about a seventh of the total structure (to which a tentative formula $C_{62}H_{88-92}N_{14}O_{13}PCo$ has been given), it is clear that the chemistry of this vitamin will be a tough nut to crack.

M.O.S. Appoints Lockspeiser's Successor

THE Minister of Supply has appointed MR. H. M. GARNER, C.B., to be Chief Scientist of the Department, in succession to Sir Ben Lockspeiser (now director of the D.S.I.R.). For the last three years Mr. Garner has been Principal Director of Scientific Research (Air) in the Ministry of Supply. He is 58 this month.

Stradling's New Appointment

SIR REGINALD STRADLING, F.R.S., took up his appointment as Dean of the Military College of Science at Shrivenham on October 1. The College gives an excellent training in engineering and science, and Sir Reginald Stradling is admirably qualified to succeed the late Prof. C. H. Lander as its Dean, with his experience of the Army in the First World War in which he served in the Royal Engineers, his early knowledge of the academic world gained as a Lecturer on Civil Engineering in the University of Birmingham and later as Head of the Civil Engineering department

of Bradford Technical College, and his long experience of government work. His duties in the war as Chief Adviser responsible for research in the Ministry of Home Security brought him into contact with senior officers and scientists of all types.

Sir Reginald Stradling is best known for his work as Director of Building Research from 1924 to 1939 in which capacity he raised the Building Research Station to the status it now holds.

At the end of the war Sir Reginald Stradling was appointed Chief Scientific Adviser to the Ministry of Works.

LETTER TO THE EDITOR

SIR,

In DISCOVERY (April 1948) you published an article on "Aspects of Bee Behaviour", by Colin Butler. In this article Butler gave a short account of some experiments of Karl von Frisch. In DISCOVERY (September 1949) you gave a further note describing how the bees orientate themselves by means of the polarisation of light.

I have been a student of ant behaviour for some years and am therefore very interested in the behaviour of their close allies the bees and wasps although I myself have done no research on these groups of insects. I have, therefore, been most interested to read about these experiments of von Frisch and also to read the many comments and conclusions that have been drawn from them in both the scientific and popular press. More recently I have taken the trouble to read through once again all the papers which von Frisch has published on this subject since 1922 including, of course, the original of the authoritative English translation (published in the *Bulletin of Animal Behaviour*, 1947) of his major paper on the subject which was published in the Swiss journal *Experientia*.

There is no question that this ability of the bees to communicate the distance at which, and the direction in which, food may be found, is remarkably well developed, but I am worried about certain parts of these experiments and also about some of the interpretations which have been placed on them by the popular press.

There would seem to be no question that the bees do perform two distinct types of dances, *a round or circular dance* when the food is near the nest and *a waggle (or figure-of-eight) dance* when the food is farther away. At least this happened in the majority of cases recorded. It also seems certain that the bees returning from a distance will dance the straight part of their waggle dance at an angle which bears a direct relation to the sun. This is not very surprising since, as Frisch himself points out, Brun demonstrated that the sun, or alternatively light and dark patches of cloud, play an important part in the orientation of many ants. Santschi also showed in some experiments that he did at Tunis, that foraging ants can be led astray and diverted from their course if the observer reflects the sun in a large mirror.

I do not find it difficult to accept the fact that the bees dance differently when they find food near the nest or farther away from the nest, nor that they indicate with the straight part of the dance the direction from which they have come (either symbolically as when the dance is done on a vertical, or actually when the dance is done on a horizontal plane), but I do find it difficult to believe, in view of my many experiments with ants, that there is a conscious or purposeful communication between the returning bees and those in the hive. I think that this is an important point which has not been sufficiently stressed. Although the type and direction of the dance does apparently inform the bees in the nest about distance and direction—at least to some extent—there is no evidence in Frisch's experiments that there is a purposeful element involved in this communication.

With regard to the data of the experiments themselves I do find certain points very unclear. For example, will bees which have never foraged at a distance respond to the waggle dance? From his experiments reported in *Experientia* it would seem that they do not easily do so since only two out of fifteen near-feeding bees responded to the dance of the far-feeding bees. On the other hand in the same experiments ten out of seventeen of the far-feeding bees responded correctly to the round dance of the near-feeding bees. Now this to my mind raises an important point. The far-feeding bees must have been round and about the nearer feeding places at some time, if only on their way to their more distant feeding grounds. The near-feeding bees, on the other hand, may never have been farther away than the near feeding place. I think in fact that these results are a reflection of this. What I should like to know is what happens when the experiments are conducted with an entirely new brood that have never left the nest; what happens, for example, when they are brought into contact with a few marked bees which have always foraged at a distance from the nest; will they then automatically respond to the waggle dance and forage at a distance, or will they not do this until they have already themselves foraged at a distance and themselves executed a waggle dance? Such an experiment would obviously be difficult to control. It would have to be certain that the newly born bees were not following the older bees and preferably the older bees would have to be foraging in a district which is strange to them, but I think that it should be done.

Reading through Frisch's experiments I find few statements which show me that such control measures were taken. Most of the experiments seem to have been conducted in districts over which the worker bees had already foraged. I do not, as I have already said, doubt the accuracy of Frisch's observations on the two dances and the orientation, nor do I question the importance of his work on this aspect of bee behaviour. But, from his experiments as at present presented, it would seem to me that there is not, as many people have been led to believe—possibly from misreading or misunderstanding the reports—some mysterious conscious 'language' by means of which the bees inform one another of certain things to do with foraging and finding good sources of food. A more probable explanation would seem to be as follows. When a bee has learnt to forage at one particular spot either distant or near at hand, it finds itself doing a little dance when it returns home laden with nectar or pollen. After it has done this a few times it will recognise this dance in other bees and will thus be stimulated by seeing this behaviour (which itself is stimulated by behaviour which our bee has already indulged in) to want to go and indulge in that behaviour yet again. There is no question of a bee coming in and dancing to inform the other bees; it is more reasonable to think that those bees which have already done the thing which the incoming bee has just been doing may be stimulated to go and do it again. What I do find remarkable, and what Frisch does not clearly explain, is that some bees will be stimulated to go and look for a feeding place when no dance has been performed. I am not clear from his accounts of his experiments whether this only applies when it is a question of the renewed presence of food at an old source, or whether it does sometimes occur when there is an entirely *new* source of food. If it occurs in the latter case it must be presumed that the bee setting out somehow acquires the knowledge of the direction from which the other bee has come, and is at the same time one which is already used to foraging at the same distance from the nest.

I have not yet seen the full report of the experiments which are concerned with the recognition of the different polarisations of light by the bees, but from your report in the September issue it does not seem to me at all certain that the concept that the bees recognise the polarisation of light is necessary. If they can already orientate themselves, like the ants, from a cloudy sky, or even a blue sky with little cloud, may not they recognise parts of that sky in a mirror; or, if there is no cloud, may they not recognise the angle from which the sun is shining without, in fact, being sensitive to the actual polarisation of the light?

The behaviour of the ants is more remarkable than that of the bees in many ways (a fact which is possibly a reflection of their terrestrial habits which cause them to have contact with many more obstacles and other animals than the bees do in their aerial flight) but they show no evidence of any purposeful or directional communication. The brains of both ants and bees are very small and are of a primitive pattern and it is, therefore, most important that we should be over-sceptical rather than the opposite in interpreting their behaviour. The manner in which the experiments have been publicised and interpreted has perhaps been unfortunate in that they have led the man in the street and even many biologists to drift back towards a dangerous and more human interpretation of insect behaviour. This cannot be justified.

Yours etc.,
DEREK WRAGGE MORLEY

September 29, 1949.

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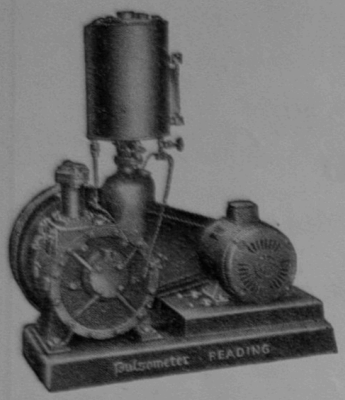

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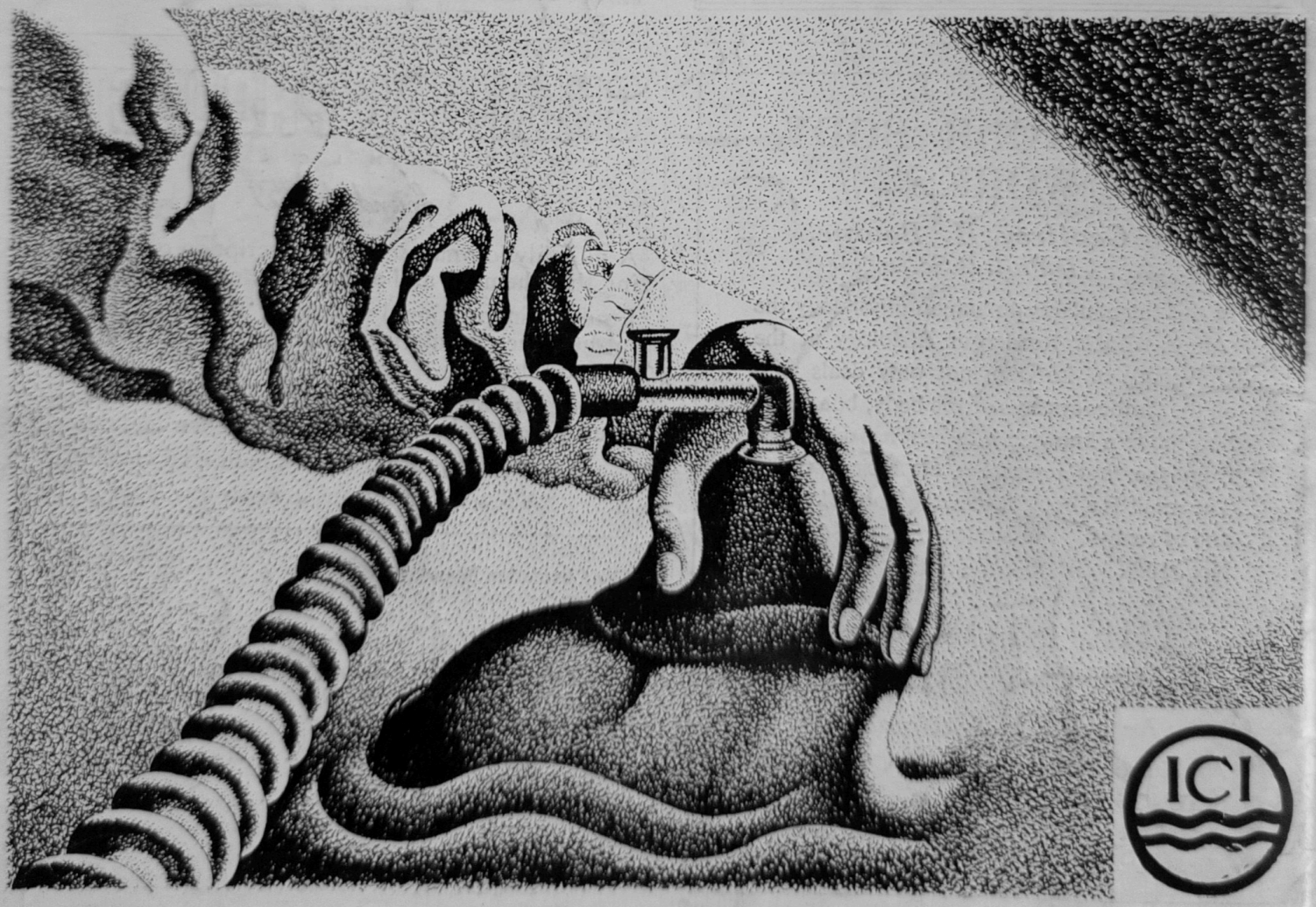
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